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THE WATER SNAKES OF SOUTHERN MICHIGAN.

HUBERT LYMAN CLARK.

THE water snakes of the genus *Natrix* offer some puzzling problems, not only to the systematist, but also to the student of geographical distribution. There can be no doubt that much of the difficulty is due to our lack of knowledge; for, unfortunately, the study of living snakes is not especially popular, and preserved specimens are so apt to lose their normal colors that the proper comparison of snakes from different localities becomes a matter of very great difficulty. The occurrence of a red-bellied water snake in southern Michigan has been known for many years, but its relation to the common water snake, *Natrix fasciata sipedon* (L.), has never been satisfactorily determined. It was with the hope of throwing some light upon the solution of this problem that the work was undertaken, the results of which are embodied in this paper. During the past two years one hundred water snakes captured in the vicinity of Olivet, Mich., have been examined, and careful observations have been recorded, from the living or freshly killed specimens, in regard to sex, size, proportions, and color, and the number of scale rows, gastralteges (plates on belly, in front of vent), and

urosteges (plates on ventral side of tail, behind vent). Special attention was also given to habits, food, and localities where captured. All the specimens were taken in the months of April, May, and June. While the number of snakes thus handled is not so large as had been desired, the results obtained are of sufficient interest and importance to warrant publication, in the hope that observers elsewhere will make similar records and thus enable us to ascertain the truth in regard to our common water snakes and their distribution.

NATURAL HISTORY.

Much of the country around Olivet is low and swampy; small lakes connected by more or less sluggish streams are of frequent occurrence, and even in dry summers there is no lack of water. No wonder, therefore, that water snakes are common, especially if one has learned when and where to look for them. Three easily distinguished forms occur, which are designated by Cope¹ as *Natrix leberis* (L.), *N. fasciata sipedon* (L.), and *N. f. erythrogaster* (Shaw). The first of these is the smallest and the least common. The largest specimen met with was 747 mm. in length, but all of the others were less than 700 mm. There are only nineteen rows of dorsal scales, and the olive color, with three narrow, longitudinal black stripes on the back, and a buff lateral stripe very prominent anteriorly, is also very characteristic. Cope says that this species shows "very little variation in any respect," but the few specimens I have examined show a great deal of diversity in the distinctness of the stripes and the amount of slate on the belly. Judging from what I have seen of its habits, this snake is very fond of the water, as I have never found it out of that element, except when sunning itself on branches immediately above some stream or the edge of a pond. The two snakes which are regarded by Cope as subspecies of *N. fasciata* are much more abundant than *N. leberis*, and all of my detailed observations have been made upon them. Both are very aquatic

¹ Cope, E. D. *The Crocodilians, Lizards, and Snakes of North America*. Washington, Government Printing Office, 1900.

in their habits, but *erythrogaster* (known about Olivet as the "red-bellied black snake") is more often seen away from the water, and several specimens were taken a rod or more from the nearest stream, while *sipedon* is rarely seen more than a few feet from water. Both are very active, and when once alarmed are very shy, but *erythrogaster* is decidedly the more wary and somewhat more rapid in its movements. Both swim with speed and grace and can remain under water for some time. Their food consists chiefly of frogs, toads, and fish; no other animal remains were found in the stomachs. They capture fish of considerable size,—a large *sipedon* having swallowed, just previous to capture, a sucker (*Catostomus*) a foot in length. Fish are usually, perhaps always, swallowed head first, but frogs and toads are taken either way. Both *sipedon* and *erythrogaster* will strike repeatedly and savagely when cornered, but the bite is absolutely harmless, and though the teeth may be strong enough to break the skin and draw blood, the wound is practically painless and heals quickly, unless the teeth, which are very small and easily torn from the jaw, remain in the wound. Like all of our snakes, these water snakes have a very strong odor, especially during the breeding season. This odor is due to a thick fluid secreted in glands situated at the base of the tail and opening to the exterior at the sides of the vent. These glands are 20 mm. long, more or less, and are present in both sexes, but in the male they lie above the hemipenes and are therefore less easily discovered. The secretion of *sipedon* is yellowish or brownish in color and has an odor difficult to describe but very characteristic; to me it smells slightly "burnt" and is very disagreeable. The secretion of *erythrogaster* is white or pale yellow and has a slightly acid, musky odor quite different from that of *sipedon*, and, to me, not so disagreeable. Such statements are obviously insufficient to enable another observer to make much use of them, but it is practically impossible to so describe an odor of this kind as to make it recognizable. The difference between the two kinds of snake is, however, very marked to any one smelling first one and then the other.

Both of these water snakes are accustomed to come out of the water, especially on sunny days, and lie, more or less coiled,

upon the bank, on logs in or beside the water, upon the branches of bushes overhanging the water, or upon piles of brush through the open spaces of which they can drop quietly down into the water below. Such piles of brush are their favorite spots, and one often sees three or more snakes coiled up together on the same pile. When so resting they seem rather stupid and may be closely approached and killed with a stick; but I think this is due, not to stupidity, but to reliance upon their protective coloration, for when once convinced that they are observed they will glide into the water without delay. That the coloration of both forms is protective is perfectly obvious to any one who has observed them in their natural haunts. The resemblance to an old stick, when they are lying motionless in the water or on brush piles, is so great that it is often very difficult for an unpracticed eye to detect them. They apparently frequent the same spot day after day, for weeks at least, if not too seriously disturbed. They seem to become more wary with experience; a fine large specimen of *erythrogaster* tempted me no less than six times to a certain spot, but each time he was more wary, and I failed in all my attempts to capture him. In no case were *sipedon* and *erythrogaster* found on the same pile of brush, and specimens of the two forms were never seen together or even near each other, although males of *erythrogaster* were on several occasions found mating with females of the same form, and male *sipedons* with females of their own race.

The local distribution of *erythrogaster* is peculiar. While *sipedon* is found about every pond or stream near Olivet, *erythrogaster* seems to be confined to a tract of low land, lying to the east of the village and bordering a creek which connects Pine Lake with the Olivet mill pond. This area is about a mile long and less than a quarter of a mile wide, but I know of no specimens of *erythrogaster* having been taken elsewhere. An advertisement was inserted in the local paper, offering a good price for red-bellied black snakes, and thirteen were brought to me in response, but every one was taken within the area designated. The common *sipedon* also occurs in that area but is not very frequent. It is difficult to account for this peculiar localization of *erythrogaster*, as I cannot see that

the environment is essentially different from that offered by other creeks near by.

DIFFERENCES DUE TO AGE AND SEX.

Soon after the collection of statistics was begun, it became apparent that the two sexes could be easily distinguished by external characters, and later on it was seen that the proportions of the body were different in very young snakes from what they were in the adults. (Perhaps it ought to be stated that age is assumed to be correlated with size, and snakes less than 500 mm. in length are regarded as young.) Before we pass on, therefore, to a comparison of *sipedon* and *erythrogaster*, it is important to make clear the differences which are dependent on age and sex.

1. *Relative Length of Head and of Tail, and Diameter of Eye, in Old and Young.*—If comparison is made between the five largest females and the five largest males, on the one hand, and the five smallest females and the five smallest males, on the other, of *sipedon*, it becomes clear that in young snakes the head and tail are longer in proportion to the body, and the eye is larger in proportion to the head, than in adults. While this is what might be expected, it is interesting to see how considerable the difference is. The form *sipedon* is used for comparison because the far greater number of specimens examined makes the contrast more marked. This table shows that if a snake 937 mm. long kept the same proportions when adult that were shown when it was 505 mm. long, it would have a

TABLE I.

	Length of Tail in Percentage of the Total Length.	Length of Head, to Posterior Edge of Occipital Plates, in Percentage of Length of Body.	Diameter of Eye in Percentage of Length of Head.
10 large <i>sipedons</i> , averaging 937 mm.	22.3%	3.2%	18.3%
10 small <i>sipedons</i> , averaging 505 mm.	23.1%	3.8%	20.2%

tail 6 mm. longer, a head 4.6 mm. longer, and an eye nearly half a millimeter larger than it does have. While the difference in length of tail is thus rather small, the difference in head and eye is very considerable.

2. *Relative Length of Tail in Males and Females.*—If comparison be made between the males and females of either *sipedon* or *erythrogaster*, the difference in the proportion of tail and body in the two sexes is very marked.

TABLE II.

Species.	Sex.	Number of Specimens.	Average Length.	Maximum Length of Tail in Percentage of Total Length.	Minimum Length of Tail in Percentage of Total Length.	Average Length of Tail in Percentage of Total Length.
<i>Erythrogaster</i>	♂	16	977	25.3%	22.4%	23.7%
<i>Erythrogaster</i>	♀	8	1060	21.9%	20%	20.9%
<i>Sipedon</i>	♂	33	657	26.7%	23.3%	24.8%
<i>Sipedon</i>	♀	25	808	22.5%	16.3%	21.1%

The above table includes all of the water snakes examined in which the tail was uninjured. It will be seen that while the males average very much smaller in size, the tail is very much longer than in the females. Indeed, in both *sipedon* and *erythrogaster* the maximum tail measurement for a female falls short of the minimum for a male, while the average for a female is approximately 3 per cent less than for the male. It thus appears that a snake 800 mm. long will be found to be a male if the tail is over 180 mm., and a female if the tail is less than 180 mm. Ordinarily a male snake 800 mm. long will have a tail not less than 24 mm. longer than a female of the same size.

3. *Number of Urosteges in Males and Females.*—If a comparison be made between the number of urosteges in males and females, it becomes evident that here again there is a marked sexual difference.

These numbers refer to the urosteges of one side only, the actual number being double the above, since these plates are arranged in alternating pairs. Occasionally there is one more

TABLE III.

Species.	Sex.	Number of Specimens.	Maximum Number of Urosteges.	Minimum Number of Urosteges.	Average Number of Urosteges.
<i>Erythrogaster</i>	♂	16	82	68	77
<i>Erythrogaster</i>	♀	8	71	62	67
<i>Sipedon</i>	♂	33	79	68	74
<i>Sipedon</i>	♀	25	69	58	63

urostege on one side than on the other, but in such cases the larger number was recorded. A water snake with more than 70 urosteges is (in southern Michigan) almost certainly a male, while one with less than that number is almost as surely a female, only three males, out of 49 examined, having less than 70. It is interesting to see that the number is not dependent at all upon the size of the snake. The five largest females of *sipedon* average 62.6 urosteges apiece, and the five smallest average precisely the same, while the five largest males average 72.4, and the five smallest, 72.6.

4. *Correlation between Length of Tail and Number of Urosteges.*—It is a noteworthy fact, though quite in accord with what might be expected, that there is a certain amount of correlation between the length of the tail and the number of urosteges. Thus, we find that the males of *sipedon* which have tails 25 per cent of the total length, or longer, average 75 urosteges apiece, while those in which the tail is less than 24 per cent average only 71. The females which have tails 22 per cent of the length or over average 65 urosteges apiece, while those which have tails less than 21 per cent average considerably less than 62. Thus, for each one per cent in the length of the tail of *sipedon* there are approximately three urosteges, without regard to sex or age. This correlation is not perfect, however, for long-tailed snakes sometimes have a small number of urosteges and short-tailed snakes a large number; thus, one female with a tail just 21 per cent of the body has 65 urosteges, while another with the tail 22.5 per cent has only 63. Moreover, snakes with tails of the same length sometimes differ greatly in the number of urosteges; thus in the case of two males

having tails 25.5 per cent of the body length, one has 78 urosteges and the other only 70. The accompanying diagram (I) is designed to show the variability in length of tail and in number of urosteges, and also the correlation between those two characters.

5. *Greater Variability of Females.* — One of the most interesting facts brought out during this investigation is that female water snakes are far more likely to vary from the normal than are males. This is not a matter of size, for many of the aberrations are among the small snakes, and they do not seem to be more frequent among large specimens. Thus, of 11 females over 900 mm. in length, 45 per cent were normal as regards the labial plates and number of scale rows (the points in which the variability is most marked), while of 12 snakes less than 800 mm., less than 42 per cent were normal. In both *erythrogaster* and *sipedon* there are, normally, 8 labial plates on each side of the upper jaw and 10 on each side of the lower; the normal formula therefore is $\frac{8-8}{10-10}$. Now, of the 19 male

erythrogasters examined, 16 possessed the normal number and arrangement of the labials, and of 33 male *sipedons*, 25 were normal; of 52 males, therefore, 41, or 79 per cent, were normal as regards the labials. Of the 8 female *erythrogasters*, only 4, and of 30 female *sipedons*, only 14, were normal; of 38 females, therefore, only 18, or 47 per cent, were normal as regards the labials. The 20 abnormal females show 26 variations from the normal, and of these 21, or 80 per cent, are *added* plates, while the 11 abnormal males show 16 variations, of which only 9, or 56 per cent, are added plates. Granting that these cases are too few to determine any general law of variability, they are nevertheless suggestive. Turning now to the number of scale rows on the back, we find additional evidence of the greater variability of females. The number of such rows is, normally, 23, counting where they are most numerous, which is usually about one-third of the total length, back of the head. Of the 52 males examined, 45 had 23 rows, 3 had 24, and 4 had 25; thus 86.5 per cent were normal. Of the 38 females, 29 had 23 rows, 6 had 24, and 3 had 25; thus, 76 per cent were normal. It ought perhaps to be emphasized that this increase

in number of scale rows is not correlated with size, for although the nine aberrant females average larger than most female *sipedons*, three of them average only 650 mm. and the seven aberrant males average 17 mm. less than the average male *sipedon*. From these figures it can be easily shown that about 68 males in 100 will have the normal number of scale rows and labials, but of 100 females only 36 can be expected to be normal in both respects. On looking over my list of 52 males

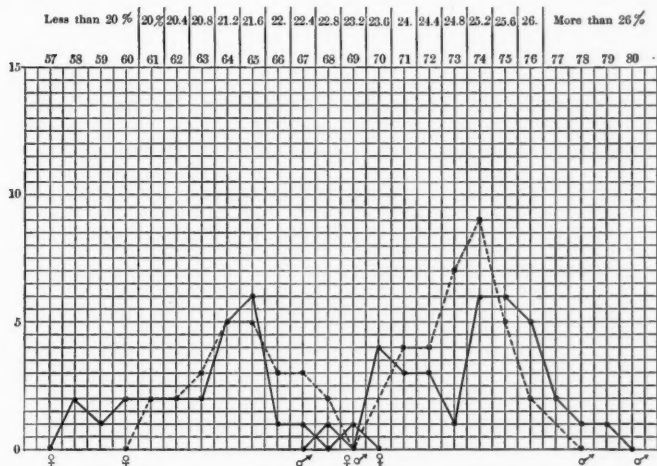


DIAGRAM I. — To illustrate the differences in the length of tail and in the number of urosteges in the two sexes of *N. f. sipedon*, and the correlation between those two characters.

— = number of urosteges. = the length of tail in percentage of total length. Horizontal lines represent the number of individuals. Vertical lines show the length of tail (upper row of figures) and also the number of urosteges (lower row of figures). Compiled from the statistics of 33 males and 25 females.

and 38 females, I find that this is about the proportion which prevails; there is, however, one less normal male and two more normal females than would be expected.

6. *Greater Variability of Lower Jaw.* — In comparing the variability of the sexes, the interesting fact was brought to light that the number of labials in the lower jaw is much more variable than the number in the upper jaw; that is to say, it is much more common to find 8–8 upper labials than 10–10 lower. Thus, of the 52 males, 50, or 96 per cent, have the

upper labials normal, while only 41, or 79 per cent, have normal lower labials; of the 38 females, 31, or 81.5 per cent, have normal upper labials, while only 22, or 58 per cent, have the lower normal. Thus, of 90 snakes, 81, just 90 per cent, have the normal number of upper labials, while only 63, or 70 per cent, have the lower labials normal. There is no well-marked difference between the right and left sides of the head, though it may be noted in passing that of 10 aberrations in superior labials, 7 were on the right-hand side, while of 32 aberrations in inferior labials, only 14 were on the right-hand side. It may further be noted that of the 10 aberrations in superior labials, all were due to *added* plates, while of the 32 aberrations in inferior labials, only 20 were due to added plates.

COMPARISON OF *SIPEDON* AND *ERYTHROGASTER*.

Having thus made clear some of the peculiarities which distinguish males from females and adults from young, in the water snakes under consideration, we may now pass on to a careful comparative study of the two so-called "subspecies." We do not need to stop and consider points of internal anatomy or those external characters which are common to both forms and serve to indicate their position in the genus *Natrix*. We will therefore take up those points wherein *erythrogaster* differs from *sipedon*, and see how marked and how constant those differences are.

1. *Size*. — There can be no question that *erythrogaster* is a larger snake than *sipedon*. As yet I have not seen a really small specimen of *erythrogaster*, while the smallest specimen of *sipedon* captured must have been born only a few days previously. The table at the top of the opposite page will make the difference in size clear.

The average *erythrogaster* is therefore considerably more than 25 per cent larger than the average *sipedon*. The contrast between the sexes is much more marked in *sipedon*, though even in *erythrogaster* the females are very decidedly larger. The absence of small specimens of *erythrogaster* is one of the most puzzling facts met with, and one for which it is difficult

TABLE IV.

Species.	Sex.	Number of Specimens.	Maximum Length in mm.	Minimum Length in mm.	Average Length in mm.
<i>Erythrogaster</i>	♂	16	1218	760	977
<i>Erythrogaster</i>	♀	8	1270	854	1060
<i>Sipedon</i>	♂	33	850	257	657
<i>Sipedon</i>	♀	25	1189	392	808

to account. Possibly the young are born later than those of *sipedon*, and careful searching in the late summer or early fall may yet reveal some of them.

2. *Proportions.* — When we come to compare the proportions of *sipedon* and *erythrogaster*, we have to bear in mind the fact that small snakes differ appreciably from large ones in the relative lengths of head and tail, and diameter of the eye. Thus, if we averaged all of the available *sipedons* and placed the averages beside those of the available *erythrogasters*, we should be led to some erroneous conclusions. For example, it would then seem that *sipedon* has a distinctly longer head than *erythrogaster*. That this is not so may be made easily apparent by taking the eight largest females and sixteen largest males of *sipedon* and comparing with the eight females and sixteen whole males of *erythrogaster*. This is as fair a choice as possible, since *erythrogaster* averages so much the larger, and the proportions of males and females are so different. The following table shows clearly the result of such comparison.

TABLE V.

Species.	Sex.	Number of Specimens.	Average Length in mm.	Length of Tail in Percentage of Total Length.	Length of Head* in Percentage of Body Length.	Diameter of Eye in Percentage of Head Length.
<i>Erythrogaster</i>	♂	16	977	23.7%	3.1%	21.1%
<i>Erythrogaster</i>	♀	8	1060	20.9%	3.1%	19.9%
<i>Sipedon</i> , largest	♂	16	726	24.5%	3.3%	19.1%
<i>Sipedon</i>	♀	8	989	20.8%	3.1%	17.5%

* In this, and in all cases where reference is made to head length, the measurement is from the most anterior point of the rostrum to the posterior edge of the occipital plates.

It will be seen that the females of the two forms agree remarkably in length of head and tail, while the male *sipedons* show only a very slight and unimportant increase over the males of the other form, and this slight increase is doubtless due to their very considerably smaller size. The one important point brought out by this table is that *erythrogaster* has a much larger eye than *sipedon*, the average difference being over 2 per cent. This is very noticeable in living and freshly killed

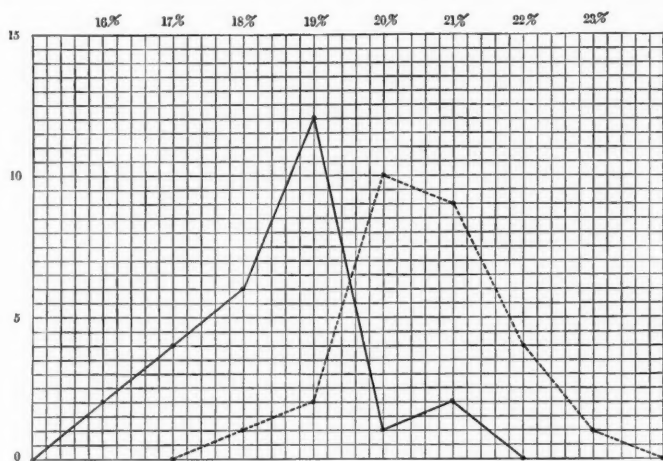


DIAGRAM II.—To illustrate the difference in the size of the eye, between *N.f. sipedon* and *N. erythrogaster*.

— = *sipedon*. = *erythrogaster*. Horizontal lines represent the number of individuals. Vertical lines represent the diameter of the eye in percentage of head length. Compiled from the measurements of 27 *erythrogasters* and 27 large *sipedons*.

snakes, but it is obvious in preserved specimens. Of the 27 specimens of *erythrogaster*, none had the eye less than 4.5 mm. in diameter, while 20 had it 5 mm. or more, and in four of these it was 6 mm. Of 63 specimens of *sipedon*, on the other hand, only six had the eye more than 4 mm. in diameter, and in only two of these did it measure 5 mm. The accompanying diagram (II) shows at a glance the relative size of the eye in the 27 *erythrogasters* and the corresponding 27 *sipedons* (8 largest females and 19 largest males). In this diagram, percentages

between 15.6 and 16.5, inclusive, are reckoned as 16 per cent, those between 16.6 and 17.5 as 17 per cent, and so on.

It is worth noting that the three *sipedons* with eyes over 19 per cent of the head length and the three *erythrogasters* with eyes over 21 per cent are all large males, while the *erythrogasters* with eyes less than 20 per cent are large females. A glance at Table V will show that there is other evidence to indicate that males have slightly larger eyes than females. The difference, however, is hardly sufficient to be easily recognized.

3. *Number of Urosteges*. — Reference to Table III will show that the male *erythrogaster* averages three, and the female four, more urosteges than the corresponding sex of *sipedon*. This is rather noteworthy in view of the fact that there is no appreciable difference in the length of the tail in the two forms. The same point may be illustrated by selecting a few examples of *sipedon*, giving the total length and the number of urosteges, and placing above each the corresponding specimen of *erythrogaster* of the same sex, which is, of all on the list, nearest in size. Thus :

{	<i>Erythrogaster</i> , ♀,	1182 mm. long	has	68	urosteges.
{	<i>Sipedon</i> ,	♀, 1189 "	"	61	"
{	<i>Erythrogaster</i> , ♀,	1030 "	"	70	"
{	<i>Sipedon</i> ,	♀, 1030 "	"	65	"
{	<i>Erythrogaster</i> , ♂,	806 "	"	77	"
{	<i>Sipedon</i> ,	♂, 794 "	"	74	"
{	<i>Erythrogaster</i> , ♂,	760 "	"	79	"
{	<i>Sipedon</i> ,	♂, 774 "	"	77	"

Although these cases were selected at random, they are purely illustrative, and not at all decisive. Examples might be given showing opposite conditions. Nevertheless, it must be admitted that *erythrogaster* seems to have, normally, a few more urosteges than *sipedon*.

4. *Number of Gastrosteges*. — In no respect, except color, is there shown such a marked difference between *erythrogaster* and *sipedon* as in the number of gastrosteges, a character which is of great importance in distinguishing different species of snakes. It is important to note here that there is no evident connection between the number of gastrosteges and sex or

size. That it is not a matter of sex is shown by the fact that the females of *erythrogaster* average 151.4 gastrosteges apiece and the males 150.8, while in *sipedon* the females average 141.7 and the males 142.9. These differences seem too small to have any significance. That the number of gastrosteges is not dependent on size is shown by the fact that the five largest *sipedons*, averaging 1066 mm. in length, have only 143.8 gastrosteges each, while the five smallest, averaging only 440 mm.,

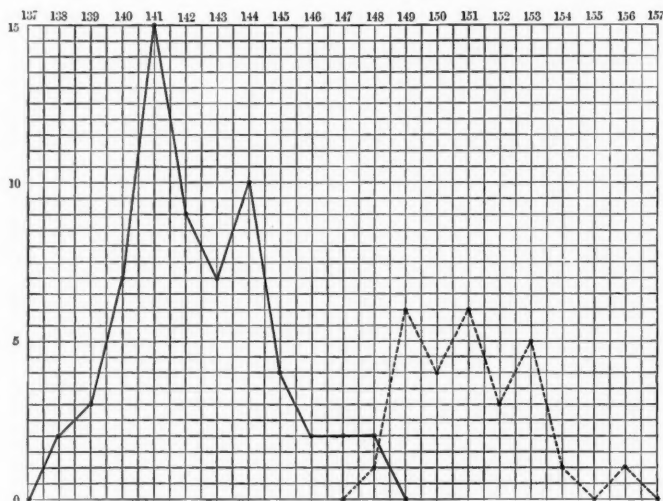


DIAGRAM III. — To illustrate the difference in the number of gastrosteges between *N. f. sipedon* and *N. erythrogaster*. The anal plate is not included.

— = *sipedon*. = *erythrogaster*. Horizontal lines represent the number of individuals. Vertical lines represent the number of gastrosteges. Compiled from the statistics of 27 *erythrogasters* and 63 *sipedons*.

have 144.2 gastrosteges each. Comparing *erythrogaster* and *sipedon*, without reference to age or sex, we find that the former has on the average 151 gastrosteges, while the latter has only 142. But the difference between the two forms is made most apparent by the accompanying diagram (III).

It will be seen at once that 148 is the maximum number for *sipedon*, and, at the same time, is the minimum number for *erythrogaster*. It ought to be stated that occasionally an imperfect

or half plate occurs at the side between two gastrosteges. This was the case in one female *erythrogaster* and in two males and two females of *sipedon*. In all such cases the extra plate has been counted as an additional gastrosteg.

5. *Color*. — In dealing with the matter of color, we meet with great difficulties, owing to the impossibility of stating differences with mathematical exactness. Moreover, in no other particular is there so much room for difference of personal opinion and so many chances for errors of judgment. Nevertheless, since it is in the matter of color that *sipedon* and *erythrogaster* exhibit their most constant and striking difference, it is absolutely essential to any proper understanding of the relation of the two forms that this difference be clearly shown. First of all, therefore, an exact description of the typical coloration of each form in life will be given, using the color names of Ridgway's *Nomenclature of Colors*.

Erythrogaster. Dorsal surface black, passing through slate black and blackish slate to nearly slate color on sides; ventral surface bright rufous, orange rufous, or even Chinese orange, shading anteriorly through saturn red to deep chrome on the throat and finally to creamy white on the chin; whole head with a reddish tinge; upper labials nearly rufous except on upper and anterior edges; outer, anterior edges of gastrosteges more or less slate color, the same shade being more or less evident on urosteges.

Sipedon. Dorsal surface dark bister with irregular, narrow, transverse bands of wood brown; beginning on the fifth or sixth row of scales, and running down vertically on sides, are broad, pale, almost whitish bands, anteriorly and posteriorly continuous with, but for the most part alternating with, the transverse bands on back; between these vertical lateral bands the scales are chocolate brown, more or less mottled with black; chin creamy white; gastrosteges creamy white, anteriorly with two semicircular spots of hazel or ferruginous, the arc of the semicircle coincident with the anterior edge of gastrosteg; farther back additional ferruginous spots appear, and these gradually merge together, at the same time becoming more and more clouded with black, so that near the vent the

gastrosteges are black with a little white on the posterior edges; urosteges mostly black, with inner edges white; head mottled, light and dark brown; lower edge of upper labials pale gray.

The colors of *sipedon* do not undergo a very marked change during a few months in alcohol or formalin, simply becoming more dull, though after the lapse of years they fade, especially if exposed to the light. The colors of *erythrogaster*, however, are completely changed in either formalin or alcohol, the black tending to become bister or clove brown and the whole under surface becoming pale cream color, with faint indications of slate on the anterior edges of the gastrosteges. The twenty-seven specimens of *erythrogaster* collected about Olivet showed practically no variation in color, except that a few had the mid-ventral line a somewhat deeper shade of rufous. In no case was there the slightest evidence of markings on the back, or of spots on the belly. The sixty-three specimens of *sipedon*, on the other hand, show a very wide range of variation, not only in the distinctness of the markings and in the amount of brown and black on the ventral surface, but also in the shade of the ground color, both dorsally and ventrally. The middle of the ventral surface is often marked with an ill-defined longitudinal area of yellowish, sometimes almost reddish yellow. Just before the shedding of the skin, the black of *erythrogaster* becomes very dull, and the ventral side a dull, almost salmon, red, quite different from the normal shade. In captivity this stage may last two or three weeks, but in freedom it is probably passed through more rapidly. In *sipedon* the casting of the skin causes a preliminary obscuring of the dorsal markings, so that in cases where they are naturally faint they may be apparently wanting.

However much specimens of *sipedon* varied from normal, none of those examined showed the slightest approach to *erythrogaster*, and it is very difficult to see how the coloration of the latter could ever have gradually developed from that of the former. While still seeking a solution of this puzzle, four specimens of *Natrix* from the United States National Museum were very kindly loaned to me by Dr. Stejneger. Of these I shall have more to say later. Suffice it to say here that they

helped me to imagine the steps by which *erythrogaster* might have developed from *sipedon*, although it by no means follows that such were the steps. The following ten are the stages that I have selected, but they are of course arbitrary, and I could easily have subdivided the sixty-three *sipedons* into a dozen color varieties, would such a division have been of any service.

TABLE VI.

Reference No.	Dorsal Ground Color.	Dorsal Markings.	Ventral Ground Color.	Ventral Markings.
1	Brown	Indistinct	Creamy or yellowish	Some brown and much black
2	Brown	Distinct	Creamy or yellowish	Some brown and much black
3	Brown	Distinct	Yellowish	Brown and black
4	Brown	Distinct	Yellowish, with red tinge	Brown and black
5	Blackish	Distinct	Yellowish rufous	Little brown; much blackish slate
6	Black	Indistinct	Yellowish rufous	No brown; much slate
7	Black	Indistinct	Rufous	Much slate on anterior half of gastrosteges
8	Black	None	Rufous	Much slate on anterior half of gastrosteges
9	Black	None	Bright rufous	Little slate on anterior edges of gastrosteges
10	Black	None	Bright rufous	Deep rufous on mid-ventral surface; very little slate

Although these are such hypothetical stages, more than half of them occur among the ninety snakes I have examined. The following diagram will show at a glance their relative abundance, but it will of course be borne in mind that the first four stages, which include all of the *sipedons*, might have been divided up into a much larger number of color varieties had it been desirable. This would not, however, have affected in any way whatever the great gap between stages 4 and 8. The only purpose of this diagram is to show plainly that gap.

Although, of course, this diagram is not really comparable with that showing the number of gastrosteges, since we are dealing here with a purely artificial arrangement and not with

exact numerical series, yet it is interesting to see how the separation of *erythrogaster* from *sipedon*, so evidently shown by the diagram of gastrosteges, is emphasized by this diagram of color.

6. *Variability*.—It has already been shown that female water snakes are more variable than males in the number of scale rows and labials. It is interesting to see that in both these

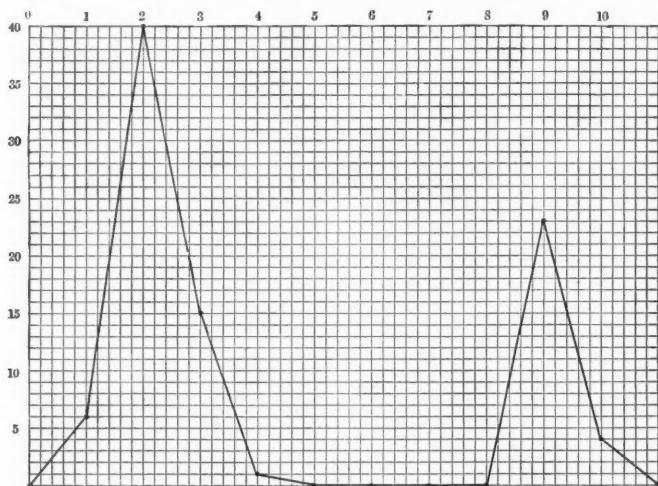


DIAGRAM IV.—To illustrate the difference in color between *N. f. sipedon* and *N. erythrogaster*. The numbers at the left indicate the number of individuals. The numbers at the top indicate the type of coloration as given in Table VI. Compiled from the records of 27 *erythrogasters* and 63 *sipedons*.

respects, as well as in color, *sipedon* is far more variable than *erythrogaster*. This is clearly shown by the table on the opposite page.

It may further be stated that there are two specimens of *erythrogaster*, one male and one female, which are apparently normal in every respect, as they have the average number of gastrosteges (151) and of urosteges (77 and 67 respectively), the proper number of labials on each jaw ($\frac{8-8}{10-10}$), and the proper number of scale rows (23). Such a normal individual of *sipedon* is not to be found among my 63 specimens. In Table II may be found another illustration of this same point, for it

there appears that the range of variability in the length of tail is over 10 per cent in *sipedon* and only a little over 5 per cent in *erythrogaster*. We have already seen that *sipedon* is much more common and much less restricted in its range than *erythrogaster*, and since it is clearly much more variable, these facts serve as an excellent illustration of the generally accepted belief that common and wide-ranging species are the most variable.

TABLE VII.

Species.	Sex.	Number of Specimens.	Number with Upper Labials, 8-8.	Percentage Normal.	Percentage for Species.	Number with Lower Labials, 10-10.	Percentage Normal.	Percentage for Species.	Number with 23 Rows of Scales.	Percentage Normal.	Percentage for Species.	Number Normal in all Three Particulars.	Percentage Normal.	Percentage for Species.
<i>Erythrogaster</i>	♂	19	18	95%		16	84%		18	95%		15	79%	
<i>Erythrogaster</i>	♀	8	7	87.5%	92%	4	50%	74%	8	100%	96%	4	50%	70%
<i>Sipedon</i>	♂	33	32	97%		25	76%		27	81%		19	57.5%	
<i>Sipedon</i>	♀	30	24	80%	89%	18	60%	68%	21	70%	76%	12	40%	49%

THE SYSTEMATIC POSITION OF *ERYTHROGASTER*.

With these facts before us, we may well consider what light they throw on the real relationship of the red-bellied black snake to the common water snake. The table on the following page will help to set before us, so that they may be readily grasped, the points of resemblance and difference between the two.

In the relative length of head and tail, in the number of scale rows, and in the number and arrangement of labials, there is evident agreement between the two forms; but, on the other hand, *erythrogaster* is a larger snake than *sipedon*, the male especially averaging 50 per cent more (see Table II), the eye is very much larger, the gastrosteges are more numerous, the urosteges slightly more numerous, the color is totally different, the odor is distinguishably different, and the percentage of variability is very much less. In addition to these characters, certain peculiarities of habits and habitat help to distinguish

TABLE VIII.

Species.	Average Length in mm.	Average Length of Tail in Percentage of Total Length.	Average Length of Head in Percentage of Body Length.	Average Diameter of Eye in Percentage of Head Length.	Number of Scale Rows.	Number and Arrangement of Labials.	Average Number of Gastrotege.	Average Number of Urostege.	Color.	Color and Odor of Secretion of Postanal Glands.	Percentage of Variability in		
											Labials.	Scale Rows.	Both.
<i>Erythrogaster</i>	1019	22.3%	3.1%	20.5%	23	$\frac{8-8}{10-10}$	151	72	Black above, rufous beneath; no markings	White to light yellow; musky, slightly acid	26%	4%	30%
<i>Sipedon</i>	733	*22.7%	*3.2%	*18.3%	23	$\frac{8-8}{10-10}$	142	68.5	Brown above, cream color beneath; cross bands above, blotches beneath	Yellow or brownish; somewhat "burnt" and disagreeable	38%	24%	51%

* Average of 8 largest females + 16 largest males, for reasons already given.

erythrogaster from its more common relative. Were all our knowledge of these two snakes confined to what has been learned about them from the study of these Olivet specimens, the proper course would be simple and no one would hesitate to write *Natrix erythrogaster* as a good species. But unfortunately for the followers of such an easy course, *Natrix fasciata* is a very widely distributed and variable species, and water snakes referred to the subspecies *erythrogaster* have been taken in many parts of the United States south of Michigan, and even in Mexico. In fact, *erythrogaster* is regarded as characteristic of the Austroriparian district, and its occurrence in Michigan is looked upon as an extreme northward extension of its range.

Through the kindness of Dr. Stejneger, to which reference has already been made, there were sent me from the National Museum three specimens of *Natrix*, which were referred to *erythrogaster* by Cope, and a fourth specimen, from the Dismal Swamp, Virginia. All are females. Let us now examine these specimens carefully:

1. The specimen from the Dismal Swamp (National Museum, No. 26,256) resembles the Olivet *erythrogasters* very closely,

but is smaller than any of my specimens (712 mm.) and has a much longer head and tail proportionately. These differences may be due, however, to the measurements having been made from the preserved specimen, in which the body would naturally have shrunk more than the head or tail. So far as can be judged from preserved material, the color was originally the same as in Olivet specimens. This snake clearly throws no light on the question of relationship to *sipedon*, but it leaves little doubt in my mind that the Virginia and Michigan snakes are identical.

2. The second specimen (National Museum, No. 1350) is a small snake less than 600 mm. long, collected many years ago by Professor Agassiz at "Lake Huron." It has only 146 gastrosteges, the diameter of the eye is less than 19 per cent of the head length, and the markings on the upper surface are those of *sipedon*. The tail is broken so that the number of urosteges could not be determined exactly, and the whole specimen is so badly faded that it is not possible to say what the colors or markings of the ventral surface were in life, but there are no distinct dark markings on the gastrosteges. In spite of this, however, the snake seems to me clearly a *sipedon* and it probably never even approached *erythrogaster*.

3. The third specimen (National Museum, No. 1351) is from St. Louis, Mo., and is also an old and faded specimen, but the presence of light transverse bands, bordered with black, across the back is very evident. Underneath the specimen is practically unmarked, and it may have been rufous, like *erythrogaster*. The diameter of the eye is 23 per cent of the head length, and there are 152 gastrosteges, but there are 24 rows of scales and only 61 urosteges. The specimen is probably an *erythrogaster*, with evident indications of relationship to some *sipedon*-like form.

4. The fourth specimen (National Museum, No. 1341) is from Lansing, Mich., less than thirty miles from Olivet, and is also old and badly faded. It has the diameter of the eye 20 per cent of the head length, 151 gastrosteges, 64 urosteges, and 25 rows of scales. It is like *erythrogaster* in color, except that at intervals of 20 mm. along the middle of the back are indications of dark transverse markings.

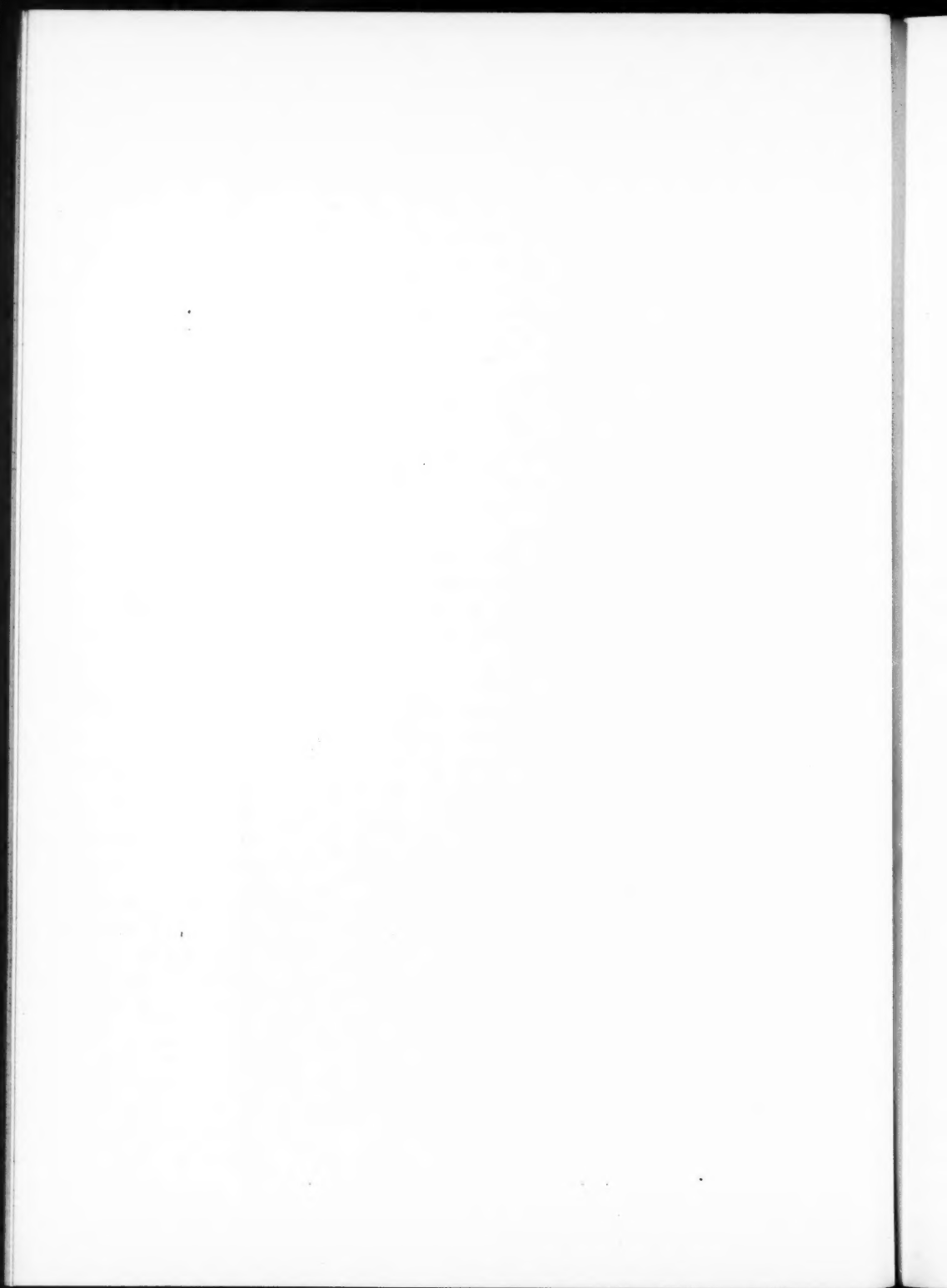
In the Olivet College museum there is a specimen of *erythrogaster*, a female, taken at Olivet in the spring of 1889, which is the largest water snake I have yet seen. The tail is broken, but careful calculation for the lost portion shows that the specimen was certainly over 1300 mm. in length. The eye is 6.5 mm. in diameter, 22 per cent of the head length; there are 154 gastrosteges and 25 rows of scales. There are no dorsal markings of any kind, but the ventral surface is mottled with a great deal of slate color along the sides, especially near the vent, on the posterior gastrosteges and the urosteges. The coloration is therefore No. 8 of Table VI.

We have here, then, three (or possibly four) snakes which seem to be what might be considered connecting links between *erythrogaster* and *sipedon*, or some other form of *fasciata*. Are they really such? Two facts must be noted: first, all are old specimens, the most recent having been taken thirteen years ago, and that one is most nearly a typical *erythrogaster*; second, all are females, the variable sex, and are aberrant in number of scale rows, urosteges, or gastrosteges. They are not, therefore, actually intermediate forms, but individuals which have varied from the normal in color as well as in some other particular. The smallest of my specimens of *erythrogaster*, a male 760 mm. long, was kept in captivity for six weeks, at the end of which time he shed his skin. Although when captured his coloration was perfectly normal, without a trace of markings, his new suit showed along the sides faint indications of lighter, vertical bands, visible only in just the right light. Might this not indicate the ancestry, as the spots on the breast of a young robin indicate its ancestry, without making the individual in any sense a connecting link?

All of the evidence so far collected seems to me to show that we have in *Natrix erythrogaster* a well-defined species of water snake, probably derived from some form of *fasciata*, though probably not *sipedon*. Possibly the separation has been completed during the nineteenth century and the specimens in the National Museum, referred to above, are some of the last connecting links, though I am inclined to regard them merely as unusually aberrant females. At any rate, what we need

now is fresh evidence and much of it. Are connecting links between *erythrogaster* and any forms of *fasciata* now to be found anywhere? Do *erythrogaster* and forms of *fasciata* breed together? Do the females of *erythrogaster* ever produce any young that are not clearly young *erythrogasters*? Do the females of any form of *fasciata* ever produce *erythrogasters*? Until some or all of these questions are answered in the affirmative, *erythrogaster* is entitled to rank as a distinct species of *Natrix*. But there is still much to learn as to its range and its breeding habits.

OLIVET COLLEGE, MICHIGAN,
August, 1902.



NEW OR HITHERTO UNKNOWN EPHEMERID
NYMPHS OF THE EASTERN UNITED
STATES.

EDWARD W. BERRY.

THE nymphs of these, our most primitive Neuroptera, are especially interesting because of their varied and great specialization, each species having solved the problem of existence in a somewhat different manner. The described nymphs are few. That of *Bætisca obesa* Say has been known and figured for some years. Needham,¹ in 1901, describes the nymphs of seven species, representing as many genera, from the Adirondack region; and a number of undetermined American nymphs are described and figured in Eaton's monograph. It is singular that these most interesting aquatic larvæ are so little known. They are very easy to rear and form a delightful addition to any aquarium. Almost any pond or stream, of whatever size, will furnish its quota of forms, and there is a constant succession of species throughout the year. Thus I found *Blasturus cupidus* extremely common during the latter part of March and the first part of April, while diligent search on May 17 failed to disclose any specimens. *Habrophlebia americana* was abundant during the last week in May, while on June 14 I could not find any trace of it.

In these brief notes special attention is directed to the structure of the gills, because they afford a convenient and admirable criterion of the relations of the various species, both to one another and to their environment, and will prove exceedingly useful as a basis for phylogenetical hypotheses when more extended observations have been accumulated.

I am greatly indebted to Nathan Banks of the Department of Agriculture for authoritative determinations of the imagos.

¹ N. Y. State Museum, Bull. No. 47.

All the specimens are from Boynton's Pond, a shallow sheet of water about one hundred feet in diameter on the outskirts of Passaic, N.J.

Habrophlebia americana Banks mss.

This fine little species was common among the floating masses of *Spirogyra* which skirt the edges of the pond; rather sedentary in habit, but very active swimmers when disturbed. They swim by rapid vertical movements of the abdomen, meanwhile holding it considerably elevated. The chief organs of locomotion are the flattened abdomen with the expanded lateral margins of its segments. The caudal setæ are weak and but thinly clothed with hairs, and can be of but little assistance in

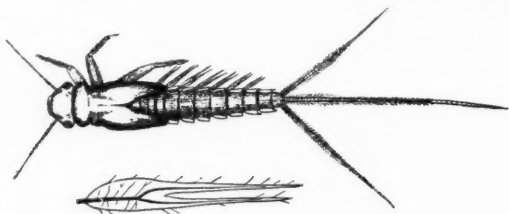


FIG. 1. — *Habrophlebia americana* Banks mss.

swimming. The abdomen is not held in a raised position when the nymphs are resting, as it is in *Callibaëtis*, for instance.

Antennæ slender, about 2 mm. long, sparsely and minutely hairy at the joints toward the base. Head wider than long, with the eyes on the posterior lateral angles. Color dark brown; margins of the abdominal segments and their lateral extensions, together with the terminal third of the caudal setæ, yellowish. Abdomen flattened; segments 3 to 6 about the same width and becoming slightly longer; segments 7, 8, and 9 rapidly narrowing, the ninth being about half the width of the third; posterior margins of segments 6 to 10 minutely toothed; lateral margins of all the segments produced more or less beneath the gills, thus protecting them when swimming. This lateral expansion increases posteriorly, and the posterior lateral angles of segments 8 and 9 are produced into a sharp spur.

Gills single, lanceolate, bilobed, similar in outline to the first stunted pair in *Blasturus cupidus*; directed laterally, borne on segments 1 to 7, and all alike except for the third, fourth, and fifth pairs being slightly larger; margins of all somewhat clothed with scattered hairs.

Caudal setæ all hairy on both sides, — sparsely so, however, and then only at the joints; angle of separation considerable; terminal third naked and lighter colored than the basal two-thirds. Middle seta longest, length 5–6 mm.

Legs rather small and weak, the third pair the longest; coxa with a row of eight tiny spines; femur abundantly spined; tibia and tarsus spined at angles and hairy, the hairs longest on the tibia. This species seems to walk backward or forward with equal facility.

Total length 6–7 mm. (figure enlarged $\times 6$); greatest width 1.1 to 1.5 mm.

These were taken the afternoon of May 24 and were fully grown, but owing to the cool weather none emerged until May 29, when one emerged; the next day (May 30) two others emerged, and the first specimen molted his subimago accoutrements and became a full-fledged ephemerid.

This is the only known species from the United States, and the only recorded locality as far as I know, although Eaton in his revision states that he has seen a specimen belonging to this genus from New Hampshire.

Blasturus cupidus Say.

This is one of the commonest spring May flies of the eastern states. Imagos have been recorded from the following New Jersey localities: Fort Lee, Staten Island, Caldwell, Westville, and Jamesburg. The full-grown nymphs were common beneath the floating debris around the pond margins during the last week in March and the first week in April. On May 17 none were to be found.

Nymphs stout, widest across mesothorax (about 3 mm.), total length 12 to 13 mm., color dark; antennæ about half as long as body (or 6 mm.); legs comparatively strong, minutely spined throughout. Comparatively slow swimmers, but active

walkers and climbers, walking with facility either forward or backward. Lateral margins of posterior abdominal segments produced into a point.

Outer caudal setæ fringed on both sides, habitually held at an angle of 60° to 70° (Fig. 2, *e*); length about 12 mm.; joints

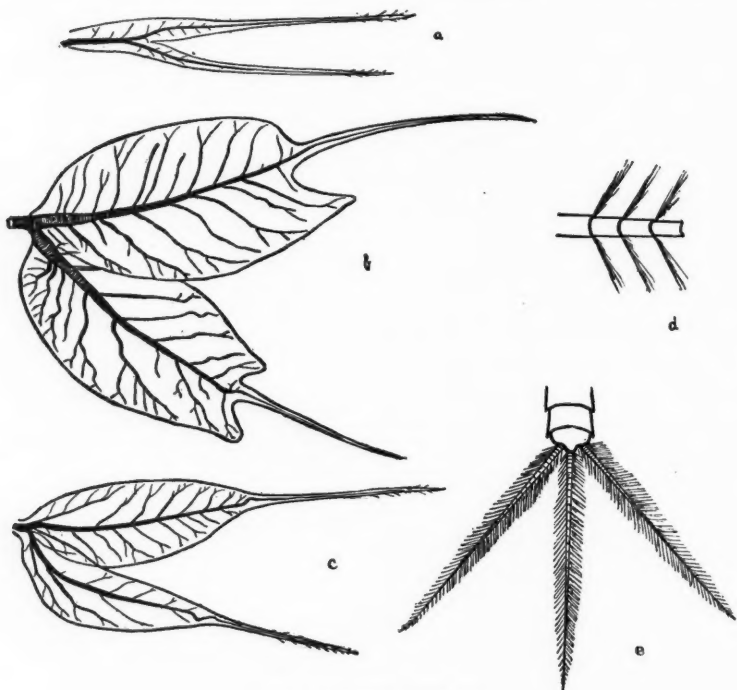


FIG. 2. — *Blasturus cupidus* Say.

over seventy, short at the base, becoming elongated toward the tip; margins of joints finely spined, hairy only at the nodes (Fig. 2, *d*).

Gills exposed, leaf-like, held laterally, on segments 1 to 7, their movement comparatively slow (about 130 per minute); on the first segment they are simple lanceolate rudiments, forked for over two-thirds their length into two slender sparsely hairy branches (Fig. 2, *a*); they are double on segments 2 to 7, ovate

in outline, their mid-veins extended into slender filaments, which are nearly as long as the gill leaf proper (Fig. 2, *b*); the gills gradually become smaller and more slender posteriorly, until on segment 7 they are lanceolate (Fig. 2, *c*). Veins reddish, thick, passing abruptly into very fine branches.

Callibaëtis ferruginea Walsh.

Imagos of this species have been taken from Canada to the southern states; none are recorded from New Jersey localities, however. The nymphs are very common beneath the floating

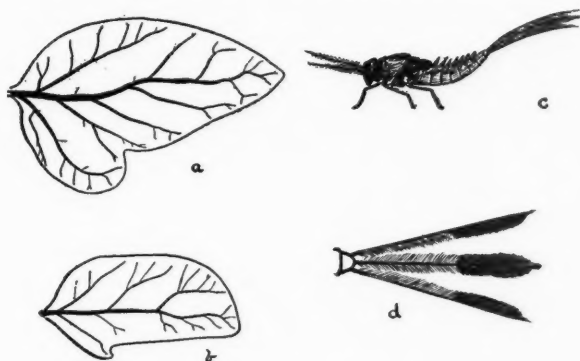


FIG. 3.—*Callibaëtis ferruginea* Walsh (spring form).

debris and *Spirogyra* masses, and appears to be the most common species in the vicinity of Passaic except for an undetermined species of *Heptagenia* from the brooks of this vicinity. I have taken them at intervals from the first week in April through July; they were more abundant, however, during the springtime.

General color light brown, sometimes greenish; eyes lateral; body widest across the mesothorax; legs about equidistant at base, weak, light colored, darker at the tips of the joints.

Gills exposed, on segments 1 to 7, simple, somewhat two-lobed, broadly oval in outline, held vertically when at rest; vibration intermittent but rapid (about 200 per minute). They

decrease regularly in size posteriorly. Fig. 3, *a* represents one of the first pair and Fig. 3, *b* one of the last pair.

Total length about 9 mm.; antennæ 5-6 mm.; caudal setæ 7 mm.

Caudal setæ abundantly fringed, the lateral ones on the inner side only; fringe three or four times as long as setæ is wide, regularly abundant, not confined to nodes except towards tip, where it is short and sparse and almost imperceptible; fringe widest on the middle third, which is strikingly dark colored (Fig. 3, *d*); lateral setæ slightly longer than terminal,

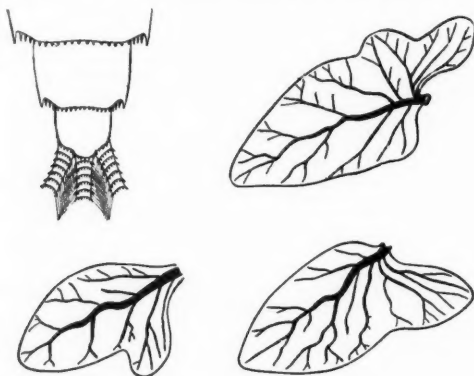


FIG. 4. — *Callibætis ferruginea* Walsh (summer form).

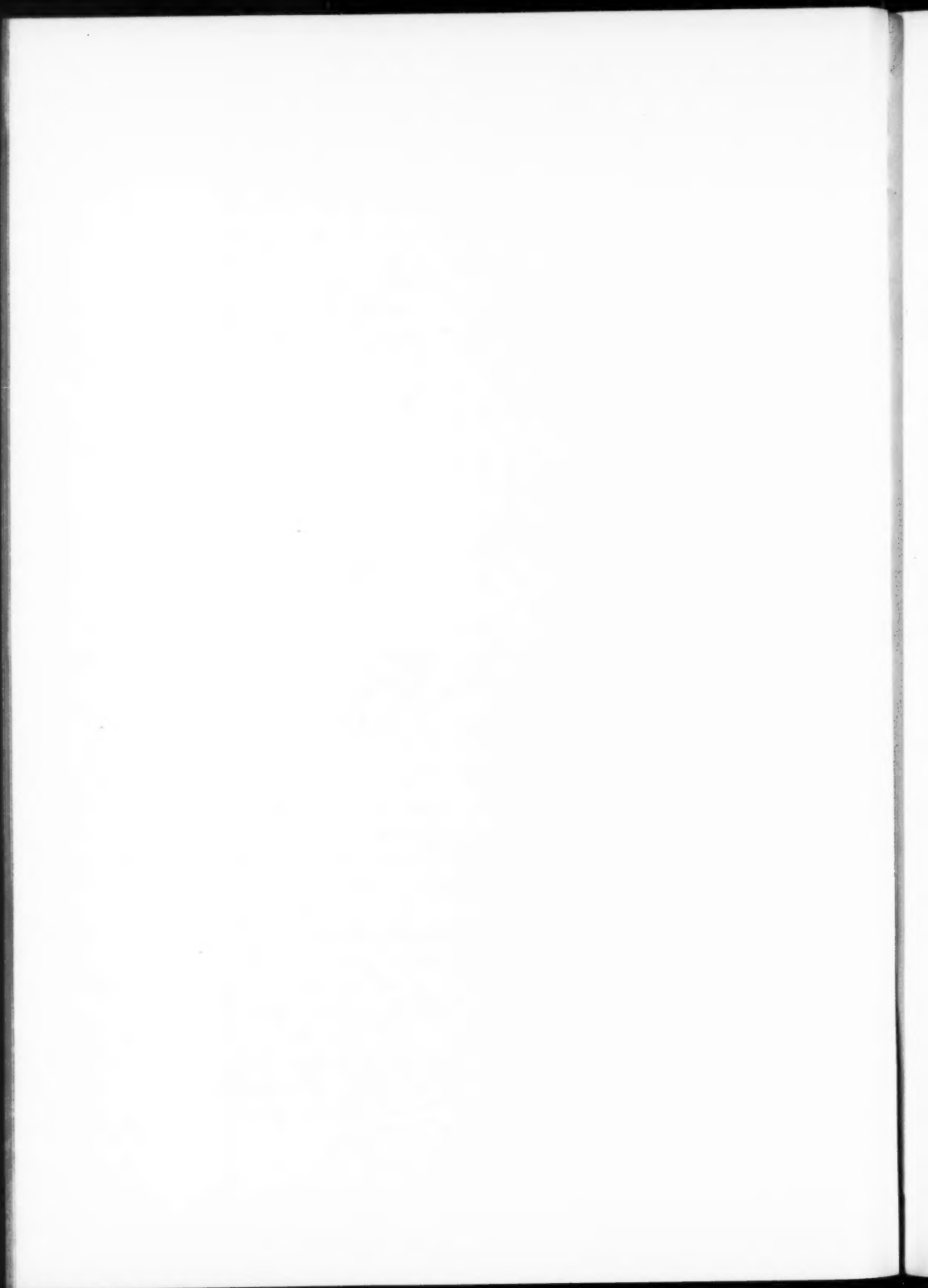
bringing their tips in a line; angle between outer setæ habitually about 30° ; active darting swimmers, as might be imagined from the oarlike caudal setæ, and correspondingly poor walkers and climbers. When at rest the abdomen is held much elevated, as in Fig. 3, *c*.

The specimens taken on June 14 (Fig. 4) differ somewhat from the preceding, and I imagine the former might have been females. One of the latter which I bred was a male, but I cannot be sure that it is the individual from which I wrote the description.

Total length 10 mm.; antennæ 5.25 mm.; setæ 7 mm.; greatest width 2.25 mm. The habitual angle at which the outer caudal setæ was held was slightly greater than in the

former case; the margins of the joints more conspicuously spined, particularly those of the abdomen, which increase in size laterally, the last one forming a decided spur at the posterior-lateral angle of the segment; gill veins somewhat stouter, and gills with a much more decided basal lobe. Collected on the afternoon of June 14. During the night four subimagos emerged, and the next afternoon the only living one molted to the imago stage.

PASSAIC, NEW JERSEY.



ON THE CLASSIFICATION OF CERTAIN GROUPS OF BIRDS.

(SUPERSUBORDERS : ARCHORNITHIFORMES ; DROMÆOGNATHÆ ;
ODONTOHOLCÆ.)

R. W. SHUFELDT.

INTRODUCTION.

For a number of years I have paid considerable attention to the anatomy of birds, and especially to the osteology of the class. This has been done chiefly with the view of enabling me sometime to draw up a provisional scheme of classification of this group of the Vertebrata. This is now well on its way toward completion, but before finishing it I prefer to await the appearance of other taxonomical schemes by other authors, either now in press or coming out in parts, as well as the publication of certain memoirs of my own on the same subject. My work on the osteology of birds came to assume such formidable proportions that I failed to find a publisher either in this country or Europe who would undertake the publication of it. Therefore I was compelled to issue it in the form of separate memoirs, or monographs, many of which have already appeared, while eight others have been accepted and will be issued in due course.

In the present contribution I offer the researches I have made in the osteology of the Archæopteridæ, the Ornithuræ, or ostrich forms, and the Odontoholcæ. In doing this I have gone most carefully over all the literature on the subject that was available to me, and have examined a number of the skeletons of the birds contained in these groups, by far the larger share of which belonged to the department of comparative anatomy of the United States National Museum, to which institution I am especially indebted for the facilities it extended

to me. My thanks are particularly due to Mr. Lucas for his many courtesies in bringing the material before me, and to the free use of the collections under his charge. I am also indebted to my friend the late Prof. E. D. Cope, the late Prof. O. C. Marsh, and others for suggestions.

With these brief prefatory remarks given by way of explanation we may next proceed to the consideration of Order I of the class Aves, — the Saururæ, and the other groups enumerated above.

I. ORDER SAURURÆ.

SUPERSUBORDER.	SUBORDER.	SUPERFAMILY.	FAMILY.
Archornithiformes.	Archornithes.		Archæopteridæ.

So widely known is the fossil material representing the celebrated species of *Archæopteryx* that any very extended description of it would be quite unnecessary in this place. A great deal has been written upon the two species of this extinct genus since 1861, when Hermann von Meyer described the first specimen, which was probably nothing more than the impression of a primary feather discovered in the lithographic slate of Solenhofen, in Bavaria, a deposit belonging to the Upper Jurassic.

Two years afterward Owen described the first skeletal remains found in the same locality, it being largely the posterior part of the bird now known to science as *Archæopteryx lithographica*. A far more perfect example was found in 1877, from which the skull and the greater part of the skeleton could be made out. The first of these specimens is now in the British Museum, and the last one in the Museum of Berlin. It has never been the fortune of the present writer to have personally examined any of this material. In addition to the literature of the subject, however, I have before me a fine photograph of the British Museum specimen, which was secured by the Century Company of New York City to illustrate an article of mine in the *Century Magazine* (January, 1886). The majority of those illustrations were reproductions of my own drawings and among them a restoration I had made of *Archæopteryx*, but had I this restoration to make again, it would present a very different appearance, especially in the covering of the

body and the characters of the long tail. It favors its reptiloid organization too much, for it is probable that the typical species of the genus *Archæopteryx* were about seventy-five per cent bird and but twenty-five per cent reptile. If the fossil remains of the earlier ancestral stock of this group of forms are ever discovered we will meet with types presenting just as much of the reptile in their organization as bird, but they will not have developed the feathers that *Archæopteryx* possessed, nor will the hind limbs be as ornithic in structure. Some of these long-tailed reptiloid birds were about the size of a fish crow, while others were much larger. As is well known, they had a long, lizard-like tail composed of twenty-one vertebræ, and into the skin that covered these were inserted twenty-one pairs of conspicuously developed tail feathers, a pair to each vertebra. Morphologically, these long and slender joints were distinctly reptile in character, and doubtless had quite as much motion, individually and collectively, as do the vertebræ in any of our larger whip-tailed lizards of the present time. The comparatively small, pyramidal skull of these ancient forms was much flattened above, with its occipital aspect truncated obliquely. Either orbital cavity was large, and true teeth in grooves, or sockets, armed either mandible.

Reptilian characters largely predominated in the remainder of the vertebral column of *Archæopteryx*, for the articular surfaces of such of the vertebræ as have thus far been examined and studied are flat, and the sacral ones were few in number.

According to Marsh the sternum was represented by a single broad plate of bone, and it is likely that it developed a keel. The shoulder girdle was very birdlike, especially the os furcula. Pycraft, who has examined all the fossil specimens of these Jurassic birds, says: "The dorsal ribs have been described as wanting uncinatè processes; an unsafe conclusion, since these are often absent in the skeletons of existing birds, having been lost in maceration. The cervical ribs appear to have been much more slender than in modern birds, and to have remained movably articulated throughout life. 'Abdominal ribs,' resembling rather those of the *Crocodylia* than of the *Chameleonida*, appear to have been present."

The three bones composing one-half of the pelvis were apparently distinct, quite as much so as among the young of modern birds. Of these pelvic bones the ilium is best seen, and is said to be characteristically avian. Apart from a few transitional characters denoting the origin of the form from reptilian stock, the skeleton of the pectoral and pelvic limbs are almost entirely ornithic. Whether the avian-like humerus was pneumatic has not as yet been definitely decided. This is due to the fact that the pneumatic fossa is still concealed in the matrix. A low pectoral crest was developed, a feature we would naturally look for, as doubtless these birds could fly well. Three well-developed digits composed the skeleton of either hand; the first, or pollex, having two phalanges, index three, and medius four. All of the distal or ungual phalanges supported claws. The carpus, according to Pycraft, "probably agreed with that of modern birds; except that the distal mass of fused bones remained distinct throughout life, and that digit III was provided with a separate carpal bone." Every anatomist who has examined the pelvic limbs of these fossil forms declares that the skeleton of the pelvic limb is almost entirely avian in character, Professor Gadow having noticed that the metatarsal to the hallux digit was short and free, being directed backwards. Others have observed, as Professor Dames and Dr. Hurst, the reduction of the distal extremity of the fibula, but whether the bone stands in front of the tibia, as in *Iguanodon*, and stated by Dr. Stejneger, seems to be doubtful. The metatarsals were elongated as in existing birds, and apparently firmly ankylosed together, though their original separateness is easily made out by the presence of the sutural lines between their shafts. Including the hallux there were four toes, as in the higher bird groups of this day, and their ungual phalanges were all armed with a horny claw. *Archæopteryx* possessed a femur departing in general structure and appearance but very little from what characterizes that bone in any medium-sized corvine type of the present time, and so requires no special description. There seemed to be, however, considerable curvature to its shaft. In addition to the authorities I have already named as having contributed to the knowledge of these Jurassic birds, may be added

the names of Huxley, Dollo, Fürbringer, Romanes, Seeley, Woodward, and Zittel. Each and all of these writers have taught that, by extremely slow and gradual development in time, our existing birds were derived from ancestral reptilian forms, and that the discovery of such a genus as *Archæopteryx* need create no surprise, for it represents just such a type as we would look for far back in geologic time during the earlier transitional stages in the evolution of the class Aves.

The American Jurassic has also furnished fossil remains of another land bird, but whether arboreal or not, as was the case with *A. lithographica*, cannot be determined from the limited material. It was a toothed bird of some considerable size, and was described as *Laopteryx priscus* by Marsh, who obtained it from the Jurassic of Wyoming. It is principally represented by the posterior portion of a skull, and this, it is said, presents a somewhat struthious character. The single tooth found near this skull was more or less like the teeth possessed by *Ichthyornis*.

Beyond the fact, however, that *Laopteryx* probably belonged to the same geological age as did *Archæopteryx*, there is nothing to indicate in the remains we have what manner of appearing bird it was, much less as to whether it possessed a tail like *Archæopteryx*. It is provisionally placed here in the order *Saururæ* for convenience only.

II. ORDER ORNITHURÆ.

SUPERSUBORDER.	SUBORDER.	SUPERFAMILY.	FAMILY.
Dromæognathæ.	Struthiornithes.		Struthionidæ.
	Rheornithes.		Rheidæ.
	Casuariornithes.		Dromaiidæ.
			Casuariidæ.
			Dromornithidæ.
	Dinornithes.		Dinornithidæ.
	Æpyornithes.		Æpyornithidæ.

Fürbringer employed the term *Ornithuræ* to designate his Subclass II of birds, created to contain all existing and extinct species of this group of vertebrates not included in Subclass I, the *Saururæ*, which is represented alone by the fossil *Archæopteryx*

lithographica and its allies. Gill, Stejneger, and others have used the term Eurhipiduræ for all birds in contradistinction to the Saururæ, while the last-named author throws the toothed birds of the American Middle Cretaceous outside of it. Now as Eurhipiduræ means "fan-tailed birds," it is a term not strictly applicable, for neither the struthious birds nor the grebes possess fan tails, while it is more than likely that the representatives of the ichthyonine birds did, and this very probably was the case too with Hesperornis. As with so much that now goes in avian taxonomy, even the lizard-tailed (Saururæ) and the bird-tailed (Ornithuræ) orders can only be considered provisional divisions. However, they can do duty until the day comes when a fossil bird is discovered somewhat more reptile-like than Ichthyornis, but presenting in the skeleton of its tail a decided advance birdwards from Archæopteryx, even to the point of the first stages of the formation of a pygostyle.

SUPERSUBORDER DROMÆOGNATHÆ.

In this group it is intended to include all the existing and extinct struthionine birds which are morphologically closely allied to the ostrich (*Struthio camelus*). This will include the Dinornithidæ, but obviously exclude the Apterygidæ, the Crypturidæ, and other families that are not ostriches in any sense of the word, any more than was the American cretaceous toothed loon, the Hesperornis. It comes about as near the expression of true avian affinities to associate the tinamous with the ostriches, for the reason that the posterior extremities of their ilia and ischia have remained free, as it would be to relegate the cassowaries to the crane group, simply because in them those bones fuse together in the adult.

The supersuborder Dromæognathæ includes the following suborders, namely: (1) *Struthiornithes*; (2) *Rheornithes*; (3) *Casuariornithes*; (4) *Dinornithes*; (5) *Æpyornithes*.

Of these the Struthiornithes are represented by the existing African ostriches of the family Struthionidæ. The Rheornithes include the South American ostriches of the family Rheidæ, of which there appear to be at least three well-defined species.

The Casuariornithes include three well-marked families, — the Dromaiidæ, the Casuariidæ, and the Dromornithidæ. The Dromaiidæ contain the emeus, the ostrich birds of Australia, of which there are two species, *Dromæus novæ-hollandiæ*, and *D. irroratus*.

The second family of the Casuariornithes or the Casuariidæ includes the cassowaries, other ostrich birds of the Australian region, of which there are at least nine existing species of the genus *Casuarius*. The cassowary of the island of Ceram is one of the best known. It is the helmeted cassowary of science (*C. galeatus*). The third family, Dromornithidæ, is represented by the extinct Australian genus *Dromornis* (*Cat. Foss. Birds Br. Mus.* p. 355). The fourth suborder of the present super-suborder, or the Dinornithes, has been created to contain the family Dinornithidæ, a group susceptible of being divided into at least three subfamilies, and a number of genera (see *Trans. Zool. Soc.*, London, Vol. XIII, Part XI, October, 1895, p. 417). All these ostrich forms now appear to be extinct, although this extinction has taken place only within comparatively recent time. They were the moas of the islands of New Zealand, and were exterminated through the agency of the inhabitants of the islands. The fifth suborder of this group is represented by some five species of extinct ostrich forms of the island of Madagascar, all referred to the genus *Æpyornis*. This suborder has therefore been termed the *Æpyornithes*, and it has but the one family, *Æpyornithidæ*.

In Alfred Newton's *A Dictionary of Birds* under the article "Roc" will be found an excellent article giving the history of the discovery of these ancient ostriches, and excellent references to the literature of the subject. In the same work are found many other useful descriptions, the key to each of them occurring under the title "Ratitæ." Professor Newton there says: "According to the views adopted in this volume the sub-class Ratitæ comprehends of existing forms the orders Apteryges (kiwi), Megistanes (cassowary, emeu), Rheæ (rhea), and Struthiones (ostrich), together with the extinct *Æpyornithes* (roc) and *Immanes* (moa). As regards the relation of other older forms to the Ratitæ [as *Odontornithes* and *Stereornithes*] it seems best at present to use reserve."

It is safe to say that all of the *typical* ostrich forms are descended from some common stock. As will be seen further on, the Apterygidæ are not considered to have any special relationship with the ostriches; they are altogether a different kind of bird.

A complete account of the comparative osteology of the Dromæognathæ would of itself make a large volume, so only such information as is necessary for the purposes of classification and to exhibit the general features of the skeleton among these birds is presented here.

Several years since I wrote out a brief account of *Struthio camelus*, with the intention of setting forth the various views entertained by avian taxonomers and osteologists as to its systematic position since 1865, and to give the main features of its skeleton. A good deal that I recorded was selected from the observations of Huxley, the Parkers, and others, for many anatomists have described more or less completely the osteology of *Struthio*, and have held many opinions as to its affinities. These opinions are becoming, however, more and more unanimous. The researches of the ornithopalæontologists have also greatly assisted the solution of the problem.

In my account referred to above I pointed out further that, of all the class Aves, *Struthio camelus* Linn. is the largest species of bird in existence, and it has been known, described, and written about for ages. Of recent years some naturalists have been disposed to recognize more than one form of African ostrich, but the claim has not as yet been fully established.¹

Suborder I. Struthiornithes.

Family STRUTHIONIDÆ: *Struthio camelus*.

Newton holds the opinion that "The genus *Struthio* forms the type of one group of the subclass Ratitæ, which differs so widely from the rest in points that have been concisely set forth by Professor Huxley (*Proc. Zool. Soc.*, 1867, p. 419) as to justify us in regarding it as an order, to which the name

¹ Newton, A. Art. "Ostrich," *Dictionary of Birds*, Pt. iii, pp. 662-666. The alleged differences seem to be purely of a superficial character.

Struthionæ may be applied ; but that term, as well as Struthionidæ, has been often used in a more general sense by systematists even to signify the whole Ratitæ.¹ The most obvious distinctive character presented by the ostrich is the presence of two toes only, the third and fourth, on each foot, — a character absolutely peculiar to the genus *Struthio*.²

Huxley (*Proc. Zool. Soc.*, 1867) placed the genus *Struthio* alone in his first group, in the order (II) Ratitæ, while Garrod included all the ostrich-birds, tinamous, screamers, fowls, bustards, flamingoes, Musophagidæ, and Cuculidæ, in his order (I) Galliformes. Sclater arranges them thus :

- Subclass II, Ratitæ.
- Order XXIV, Apteryges.
- XXV, Casuarii.
- XXIV, Struthionæ.

Reichenow's scheme places them in a

- Series I,
- Order I, Brevipennes,
- Family I, Struthionidæ,

including the entire assemblage of the once-called struthious birds.

In a Subclass IV (*Eurhipiduræ*), Stejneger classifies them thus :

- Superorder I, *Dromæognathæ*.
- Order I, *Struthionæ*.
- Superfamily I, *Struthioideæ*.
- II, *Rheoideæ*.
- III, *Casuaroidææ*.
- Family I, *Dromaiidæ*.
- II, *Casuariidæ*.
- Superfamily IV, *Dinornithoidææ*,

followed by the remainder of his classification.

¹ At one time it was not uncommon to include the bustards among the *Struthionidæ* !

² Remains of a true ostrich have been recognized from the Sivalik formation in India, and the petrified egg of an apparently allied form, *Struthiolithus*, has been found in the south of Russia. Among the more important treatises on this bird may be mentioned: E. D'Alton, *Die Skelete der Straussartigen Vögel abgebildet und beschrieben*, folio, Bonn, 1827 ; Professor Mivart, "On the Axial Skeleton of the Ostrich" (*Proc. Zool. Soc.*, vol. viii, p. 385) ; M. Alix, *Essai sur l'appareil*

Fürbringer, in an order Struthionithes, creates a suborder Struthioniformes, which is further subdivided into a "gens," Struthiones, and the family Struthionidæ. The Struthioniformes is an "order" in Dr. Sharpe's systematic arrangement of the class, an arrangement he clearly sets forth in his *Hand-List of Birds* (Vol. I, pp. 1-8, London, 1899). And thus we might proceed, giving one classificatory scheme after another, each and all practically presenting the same idea as to the position of the ostrich in the system. Reichenow's scheme, however, is a little antiquated now, while I hardly think that all naturalists will agree with Garrod in placing the cuckoos and flamingoes in the same "cohort," and these in the same order with the ostriches.

Huxley has said (*Proc. Zool. Soc.*, 1867, p. 419) the Afro-Arabian genus *Struthio* is the type of one group of this order (Ratitæ) characterized by:

1. The prolongation of the maxillary processes of the palatine bones forwards, beneath the maxillo-palatines, as in most birds.
2. The thickening of the inner edges of the maxillo-palatines, and their articulation with the facets upon the sides of the vomer.
3. The shortness of the vomer, which does not articulate with either palatines or pterygoids posteriorly.
4. The slight, or wanting, ossification of the prefrontal processes of the primoidal cranium.
5. The union of the bodies of the sacral vertebræ with the anterior ends of the pubes and ischia.
6. The presence of two shallow notches on each side in the posterior margin of the sternum.
7. The proportions of the fore limb. The humerus is about equal in length to the distance between the pectoral arch and the ilium, and is therefore much longer than the scapula. The antibrachium is not half as long as the humerus. The manus possesses the ordinary three digits; and two of these, the radial and the middle, are provided with claws.
8. The union of the pubes in a symphysis.

locomoteur des oiseaux (Paris, 1874); and Professor Macalister, "On the Anatomy of the Ostrich" (*Proc. Roy. Irish Acad.*, vol. ix, pp. 1-24).

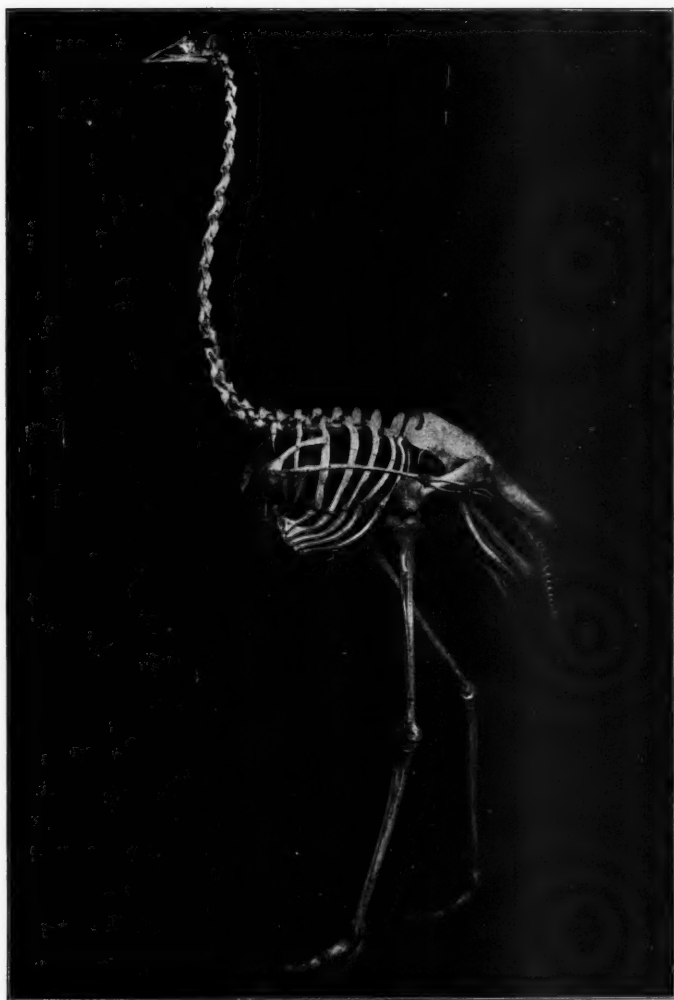


FIG. 1.—Skeleton of ostrich (*Struthio camelus* Linn.). Subadult, much reduced.
No. 13,806, Coll. U. S. Nat. Mus.

9. The abortion not only of the hallux, but also of the distal end of the metatarsal bone and of the phalanges of the second digit of the foot, whence the foot is two-toed.

10. The presence of thirty-five precaudal vertebræ.

In the same place Huxley gives the following osteological characters for the Ratitæ, or the "struthious birds," which "differ from all others in the combination" of these peculiarities (p. 418).

1. The sternum is devoid of a crest, and ossifies only from lateral and paired centers.

2. The long axes of the adjacent parts of the scapula and coracoid are parallel or identical. The scapula has no acromial process, nor has the coracoid any clavicular process; at most there are inconspicuous tubercles representing these processes.

3. The posterior ends of the palatines and the anterior ends of the pterygoids are very imperfectly, or not at all, articulated with the basisphenoidal rostrum, being usually separated from it and supported by the broad, cleft, hinder end of the vomer.

4. Strong "basipterygoid" processes, arising from the body of the basisphenoid and not from the rostrum, articulate with facets which are situated nearer the posterior than the anterior ends of the inner edges of the pterygoid bones.

5. The upper, or proximal, articular head of the quadrate bone is not divided into two distinct facets.

In his *Anatomy of Vertebrated Animals* Huxley has likewise pointed out that the cervical vertebræ in the Ratitæ have short transverse processes and ribs, disposed very much as in the Crocodilia, and I find that the ultimate vertebra of this series in the ostrich bears a pair of free cervical ribs (see Fig. 1). There appear to be nineteen of these cervical vertebræ, and six free dorsals, the latter developing lofty neural spines that gradually increase in height from before backwards. Fourteen or fifteen free caudals are also found in the chain, and these terminate with a stumpy pygostyle.

The dorsal ribs and their hæmapophyses are strong and substantial; the later exhibit a peculiar curving, and the epipleural appendages of the former are aborted in subadult individuals. Two pairs of short pelvic ribs are seen.

Sir Richard Owen, who published a great deal about the osteology of ostriches and their kin, both living and extinct, says of the sternum of *Struthio camelus* that "it is broader in proportion to its length, and subquadrate in the ostrich," and that in "all these keel-less sternums ossification begins, as in the ostrich, by a pair of centers expanding until they meet and coalesce in the middle line, and thence, according to the stimulus of the growth and pressure of the pectoral muscles, extending, as a keel, into the interspace."¹

In the pelvis of *Struthio* the ilia are long and narrow, their postacetabular portion being thoroughly and widely separated from the ischium upon either side (Fig. 1.), while in front the preacetabular region is shorter and much concaved externally. Huxley says: "In *Struthio*, alone, among birds, do the pubes unite in a median ventral symphysis. Another, not less remarkable circumstance, in the ostrich, is, that the 31st to the 35th vertebræ inclusively (counting from the atlas) develop five lateral tuberosities. The three middle tuberosities are large, and abut against the pubis and the ischium. In these vertebræ, as in the dorsal vertebræ of *Chelonia*, the neural arch of each vertebra shifts forward, so that half its base articulates with the centrum of the next vertebra in front; and the tuberosities in question are outgrowths, partly of the neural arch, partly of the juxtaposed vertebral centra, between which it is wedged. Hence, in young ostriches, the face of each tuberosity exhibits a triradiate suture."²

A conspicuous propubis is developed in the case of *Struthio*, and this has been figured by Owen (*Anat. Vert.*, Vol. II, p. 36, *m*), but in that figure the peculiar structure to which attention was invited by Garrod is not shown; this consists of a small osseous plate attached to the pubis, that is partly surrounded by cartilage.³ Forbes speaks of "this paper, written in conjunction with Mr. Frank Darwin," and points this out as the principal point of interest, and refers to it as "a peculiar nodule of bone lying on the center of the pubis and, in some respects,

¹ *Anat. Verts.* vol. ii, pp. 24, 25.

² *Ibid.*, pp. 251, 252.

³ Garrod, A. H. *Coll. Sci. Papers*, p. 99.

similar to the 'marsupial' bone of the implacental Mammalia and its corresponding fibrous representative in certain Carnivora."¹ As it has not yet received any special name it might be called the *suprapubic ossicle*. In Garrod's figure, where it is given, the pubis and ischium are firmly united posteriorly, as is also the case in Owen's figure, cited above, while in the pelvis of the ostrich in the collection of the United States National Museum these bones are distinctly independent of each other posteriorly (Fig. 1). Perhaps these do not unite until the bird is greatly advanced in age, and that this specimen is in a subadult stage of growth, which is the more likely as the epiphyses of the proximal extremities of the tarsometatarsals have not as yet coössified with the shaft.

Owen says in "the ostrich the two clavicles are distinct from each other, but are severally ankylosed with the coracoid and scapula, so as to form with them one bone on either side."

In the pectoral extremity the humerus of the arm is reduced to a mere curved and slender rod of bone, with slightly enlarged ends; while the radius and ulna of the antebrachium are even more decidedly aborted.

In *The Ibis* and in *The Philosophical Transactions of the Royal Society of London* (1888) W. K. Parker has given instructive figures of the manus of *Struthio camelus*, and they go to show that in the adult individual the radiale and ulnare ossicles of the carpus are separate and in bone. The phalanges have a most reptilian look, and the terminal joints of all three fingers are distally armed with a free, movable claw.

The pelvic extremity of *Struthio* is powerfully developed, all the bones present being massive and strong. Both the proximal end of the femur and its distal condyles are greatly enlarged. A patella is not developed in bone. The tibiotarsus and tarsometatarsus are straight, and of nearly the same length. The distal end of the latter is modified for the articulation of the third and fourth digits, the only two toes possessed by this bird.

The cnemial process of the tibia is ossified by a separate epiphysis, in common with *Rhea*. Owen says the pneumatic

¹ Forbes, W. A. *Coll. Sci. Papers*, p. 203.

foramen of the femur in the ostrich is situated posteriorly rather than in front, as it is in nearly all other birds, while the "epicnemial process" of the tibiotarsus "extends forward, without rising above the level of the proximal surface, and contracting to its termination, there divides into small pro- and ecto-cnemial processes; the latter the shortest and tuberos."

As for pneumaticity, the bones of an ostrich enjoy a greater degree of it than do those in the case of any of the true *Laridæ*.

Struthio camelus is, with respect to existing birds, most nearly related to the South American ostriches, the various species of *Rhea*.

The late T. J. Parker, in his admirable memoir "On the Cranial Osteology, Classification, and Phylogeny of the *Dinornithidæ*" (*Trans. Zööl. Soc., London*, Vol. XIII, Part XI, October, 1895), gives very complete tabular schemes comparing the cranial characters of several of the supersuborders of the *Dromæognathæ*, and from these it will be seen that a number of excellent characters distinguish the cranium of *Struthio* from that of *Rhea*.

Suborder II. Rheornithes.

Family: RHEIDÆ.

In the genus *Rhea*, the only genus of the present family, are contained those ostrich-like birds of South America, commonly known in Europe as *nandu*. According to Newton there are at least three species of these, *viz.*, *R. americana*, *R. darwini*, and *R. macrorhyncha*. Considerable has been written upon their osteology, but more particularly has the skeleton of *Rhea americana* been described, which received the attention of Huxley, of the Parkers, and of not a few others. Nearly all recent authoritative taxonomers place these birds in an order, coequal with the order occupied by the ostriches proper (*Struthio*).

Some of the special osteological characters of *Rhea* have been pointed out by Huxley, thus:

1. The maxillary processes of the palatines are short and unite with the inner and posterior edges of the maxillo-palatines.

2. The maxillo-palatines are thin, fenestrated plates, which do not articulate with facets on the edges of the vomer.
3. The vomer is as long as it usually is in birds, and articulates behind with the palatine and pterygoid bones.
4. The prefrontal processes are little ossified.
5. The bodies of the proper sacral vertebræ do not unite with the pubes or ischia ; and the centra of the sacral vertebræ, which ossify late, are extremely elongated and slender.
6. The short sternum narrows posteriorly and presents a notch in the middle of its posterior edge.
7. The length of the humerus exceeds the distance between the shoulder girdle and the ilium, and is of course greatly longer than the scapula. The manus has the same conformation as that of *Struthio*.
8. The pubes are free, but the ischia unite beneath the urosacral vertebræ.
9. The hallux is absent, but the second, third, and fourth digits are complete.
10. There are only thirty-two precaudal vertebræ. (*Proc. Zool. Soc.*, 1867, pp. 420-422.)

As in the case of *Struthio*, the skeletology of *Rhea* has long been known, and Prof. Kitchen Parker has, in his famous paper "On the Osteology of Gallinaceous Birds and Tinamous," given us a few of the necessary characters for the use of the taxonomer, they being presented in connection with what is there done with *Tinamus*.

The late T. J. Parker compared the skulls of *Struthio* and *Rhea* in his memoir on the *Dinornithidæ* (see *antea*), and showed that the differences existing between these two birds, in so far as that part of the skeleton is concerned, was in his estimation of ordinal rank. These distinctions, however, in the present work are considered to be but of subordinal value.

Suborder III. Casuariornithes.

Families : DROMAIIDÆ (the emeus) ; CASUARIIDÆ (the cassowaries) ;
DROMORNITHIDÆ (extinct).

Huxley has already pointed out (*Proc. Zool. Soc.*, 1867, pp. 422, 423) that the osteology of *Casuarius* and *Dromæus* (emeu)

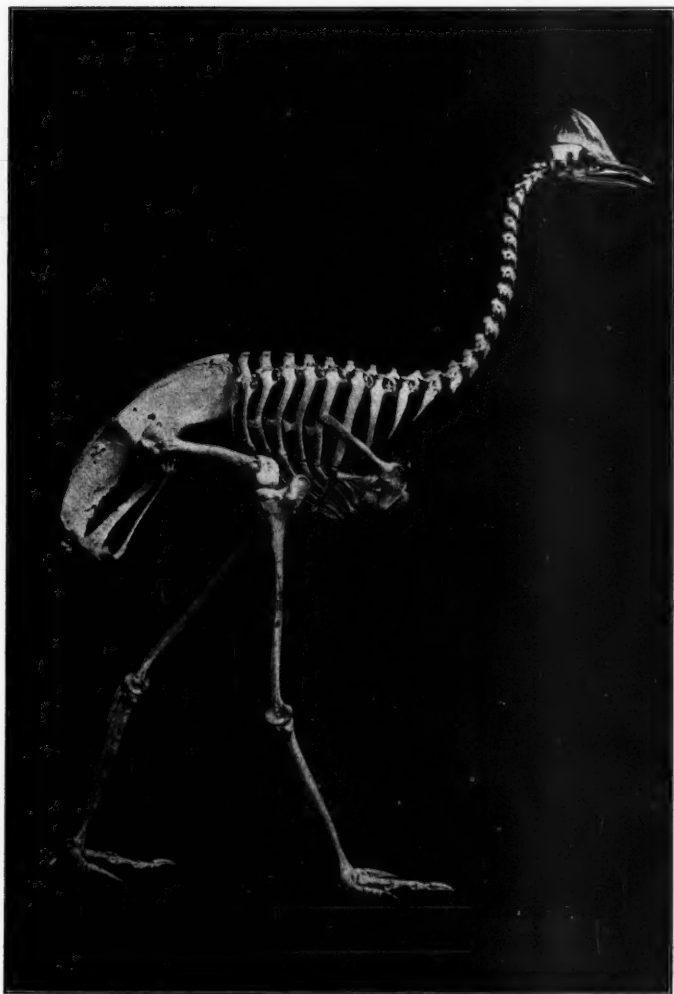


FIG. 2. — Right lateral view of the skeleton of *Casuarinus galeatus*, greatly reduced.
No. 16,964, Coll. U. S. Nat. Mus.

is much alike, and as a rule these birds have been by taxonomers properly considered to be more closely related than are *Struthio* and *Rhea* to each other. In the memoir just referred to, this eminent authority grouped the Malayo-Australian genera *Casuarius* and *Dromæus* together, and for this group gave the following osteological definitions :

1. The maxillary processes of the palatines are short as in *Rhea*.
2. The maxillo-palatines are flat, imperforate plates, which unite solidly with the premaxillæ and the vomer.
3. The vomer is long, and articulates behind with the palatine and pterygoid bones.
4. The prefrontal processes are large and well ossified.
5. The bodies of the proper sacral vertebræ do not unite with the pubes or ischia ; and the bodies of the urosacral vertebræ are very large, thick, and well ossified.
6. The sternum is long and escutcheon-shaped, at first widening and then coming to a point behind.
7. The humerus is not nearly half so long as the distance between the pectoral arch and the ilium, and is much shorter than the scapula. The antebrachium is not more than half as long as the humerus. Only one digit, the median, is complete and bears a claw.
8. Neither the pubes nor the ischia unite in the middle line of the body.
9. The hallux is absent, but the other digits are complete.
10. There are thirty-five precaudal vertebræ.

Other osteological characters to be noted in the skeleton of *Casuarius galeatus* may be thus tabulated (see Fig. 2) :

1. The light, spongy osseous core surmounting the top of the skull. In life this supports the horny helmet.
2. There are nineteen cervical vertebræ, the last three bearing big free ribs that are without epipleural processes. There are six dorsals, the first five of which have ribs connecting with the sternum by means of hæmapophyses. Only the four in the middle of the series possess epipleural appendages ; the last pair of ribs fail to connect with the sternum, as is also the case with the smaller pair of pelvic ribs present.

3. The external nostril is near the apex of the bill (Owen).

4. The clavicle is ankylosed with, or rather is a continuous ossification from the scapula; but the coracoid bone is free (Owen).

5. "In the adult Indian cassowary (*Casuarus galeatus*) there is only one carpal bone free; the manus is a solid single piece, with only one finger (the second, or index) developed, and this has only *two* phalanges — it ought to have *three*; and the distal phalanx is an inch long and carries a large claw" (Parker).¹

6. The *pelvis* resembles the pelvis in the emeu in form and in its main characters; but in *Dromæus* the ischium is, posteriorly, well separated from the ilium, while in the cassowary it fuses with it in that locality.²

7. The pelvic limb is powerfully developed: there is a big femur presenting many of the common ornithic characters, while the other bones of this extremity are also large, save hallux and first metatarsal, which are absent.

8. In the tibiotarsus the cnemial projections are conspicuously produced and rise to some extent above the proximal surface of the bone. The fibula has a massive head, while below its articulation with the shaft of the tibia it is tapering, slender, long, and styliform, ending in a free distal extremity.

9. The hypotarsus of the tarsometatarsus is a long, low median crest, and the ungual phalanx of the inner toe is especially elongated, straight, gradually tapering and distally pointed. The osseous claws of the other two toes are moderately curved, and exhibit proportions more in keeping with the remaining joints of their respective digits.

In T. J. Parker's memoir on the *Dinornithidæ* there is a tabular synopsis of the chief cranial characters of *Dromæus* and

¹"In the ripe embryo of a specimen of the Mooruk (*C. bennetti*) I find four cartilaginous carpal nuclei and three metacarpal rays: the first is very small and feeble; the second very strong and with the normal number of phalanges (*i.e.*, *three* besides the metacarpal), and the distal or ungual joint is very long and carries a long claw; the third metacarpal is about one-sixth the size of the second, and has no phalanges on it. In the emu (*Dromæus*) the second digit has two phalanges and a long curved claw." *Ibid.*, W. K. P.

² Compare the side view of the pelvis in the plate with Marsh's figure of the pelvis of the emeu (*Ornithomimus*, p. 7, Fig. 16).

Casuarius recorded in a comparative way that is extremely useful (*Trans. Zool. Soc., London*, Vol. XIII, Part XI, October, 1895, pp. 410, 411). In closing the brief account of this suborder, especial attention is invited to the fact that the distal extremities of the ilium and ischium upon either side in the pelvis of Casuarius are firmly fused together as they are in all adult birds of the order Ornithuræ, and not free as in all ostriches known to us, either existing or extinct. Although very unostrich-like, yet no one with a knowledge of birds will ever question the claim of the cassowary to a place among the existing representatives of that group.

The representatives of the family Dromornithidæ are all extinct forms discovered in eastern (Dromornis) and southern (Genyornis) Australia. They here constitute the third family of the suborder Casuariornithes, but from the fact that they are fossil forms not far removed from the existing ostrich types, they will not be dwelt upon in this article. T. J. Parker has paid no little attention to them in his exhaustive memoir cited above. (See also Lydekker, *Cat. Foss. B.*, p. 355, 1891.)

Suborder IV. Dinornithes.

Family: DINORNITHIDÆ (the moas).

Considerable literature is extant of the extinct moas of the North and South islands of New Zealand. This is amply referred to in an admirable article, "Moa," by Lydekker, contributed to *A Dictionary of Birds*, by Newton. There one will find a number of moa's bones accurately reduced and figured with the remarks that "Moas are distinguished from all existing Ratitæ in having a bony bridge on the anterior surface of the lower end of the tibia above the condyles. The tarsometatarsus has three distal trochleæ, and in most cases (according to Capt. Hutton probably all) carried a hallux. The beak (unlike that of the kiwis) is short and stout; the form of the lower jaw being either U-like or V-like. The general form of the pelvis is very like that of the kiwis; but the sternum differs by the absence of the superior notch, the more divergent lateral processes, and the abortion or disappearance of the grooves for the coracoids" (p. 578).

The late T. J. Parker, who makes three subfamilies and five genera of the family Dinornithidæ (*Trans. Zool. Soc., London*, October, 1895, pp. 417 *et seq.*), has, among other extensive osteological comparisons of these birds, pointed out the following facts, which he tabulates thus :

The Skull in the Dinornithidæ.—Occipital plane vertical or very slightly inclined backwards or forwards ; occipital condyle pedunculate ; occipital crest variable. Length of cranial roof from two to two and a half times length of basis cranii.

Mammillar tuberosities usually prominent ; basitemporal platform always well defined and separated from occipital condyle by a deep precondylar fossa.

Width at paroccipital processes from less than one and a half to more than twice length of basis cranii.

Width at squamosals from about one and three-quarters to one and a half times length of basis cranii.

Height of cranium about one and a quarter times length of basis cranii.

Temporal fossa extends mesiad, to a greater or less extent, on to parietal region ; distance between temporal ridges varies from about width of cranium at temporal fossæ to half that width. Zygomatic process short, pointed, and nearly parallel to median plane ; auditory region of skull produced into a strong squamosal prominence.

Width of orbit about half width of cranium at paroccipital processes, and almost invariably less than length of basis cranii ; interorbital septum absent or greatly reduced ; a broad supraorbital ledge, produced behind into a strong, broad, post-orbital process.

Lacrymal ankylosed with frontal, forming preorbital process ; no orbital process ; a descending process ankylosed with outer border of antorbital, and notched or perforated for lacrymal duct. Mesethmoid produced into paired horizontal triangular processes. Antorbital well ossified ; ankylosed to descending process of lacrymal ; perforated dorsally by a supraorbital fenestra of variable size.

Nasal either has a slender maxillary process, or there is a distinct maxillo-nasal bone ; meets its fellow of the opposite

side in the middle line above the ethmoid, so that the latter does not appear on the dorsal surface; premaxillary groove on upper surface of nasals extends backwards to or beyond nasofrontal suture. Premaxilla strong; body more or less elevated, and with a distinct prenasal septum; palatine processes broad and produced into more or less definite vomerine processes; width of body always more than half and sometimes one and a half times length of basis cranii. Maxilla short and narrow; maxillo-palatine a short, flat plate, produced dorsad either into an irregular shell of bone containing a large antrum, or into a thick, oblique plate containing no, or but little, trace of the antrum.

Vomer less than one and a half times length of basis cranii; consists of thin paired plates meeting each other ventrad in an acute dihedral angle, and either quite free or partially ankylosed with one another in front; firmly ankylosed behind, in fully adult specimens, with palatines and pterygoids.

Palatine a thin twisted plate, about one and a fifth times length of basis cranii; pedate posterior end produced into short mesial vomerine process; articulates at anterior end with maxilla, and posteriorly with vomer and pterygoid, with which, in fully adult specimens, it becomes ankylosed.

Mandible very strong; symphysis short, more or less flattened and ridged below; distal end more or less deflected downwards.

The best part, or an extremely useful feature in connection with Parker's work, from which the above is quoted, is the excellent series of plates that illustrate it. These are devoted to the skulls of the various genera of the Dinornithidæ (*Emeus*, *Anomalopteryx*, *Mesopteryx*, *Pachyornis*, *Dinornis*), as well as a number of colored figures, showing the relationships to each other of the cranial bones in *Emeus* and *Anomalopteryx*.

Suborder V. *Æpyornithes*.

Family: *ÆPYORNITHIDÆ* (*Æpyornis*, the roc).

This group has been created to contain the now extinct ostrich-like birds of the island of Madagascar. Fossil and subfossil specimens of eggs and bones were first accurately

described and named by Isidore Geoffroy-St. Hilaire in 1851, who named this new ally of the ostrich *Æpyornis maximus*. This was confirmed later by M. M. Alphonse Milne-Edwards and Grandidier (*Ann. Sci. Nat.*, Ser. 5, Vol. XII, pp. 167-196, Pls. VI-XVI), and now the opinion is quite universally entertained among ornithotomists that these birds were ostriches related to the genus *Struthio* of the African continent or the adjacent mainland. It has been shown, however, that the largest species of *Æpyornis* thus far discovered, as indicated by its fossil remains, was by no means as big or as tall a bird as the larger species of the *Dinornithidæ* of New Zealand.

The fossil remains in the hands of science of these Madagascan ostriches are by no means abundant, consisting principally of bones of the trunk skeleton and of the lower extremity. Max Fürbringer¹ has discussed the value of these very fully as well as the work upon them by Edwards and Grandidier. It is not considered necessary in this brief article to redescribe these fragmentary remains, and there can be no question but what the birds they represent were a group of ostriches quite as distinct as the present existing ostriches of Africa (*Struthio*).

This concludes my brief survey of the osteological characters of the fossil and existing forms of the true ostrich birds. Before concluding the present article, however, I should like to call attention to a well-known fact, that it is very generally believed that *Apteryx* is closely allied to the *Dromæognathæ*, and should be grouped with them. Many claim that the family *Apterygidæ*, to which it belongs, is in the same suborder with the *Dinornithidæ*, but the more attention I pay to the phylogeny of birds the less and less do I see the glaring evidences of the struthionine affinities of these birds.

It would seem that other naturalists besides myself have, or do, entertain similar doubts upon this point. Dr. Sharpe in his admirable work *A Review of Recent Attempts to classify Birds*, in giving his ideal plan of an arrangement of birds in a museum in order to exhibit their relationships, says on page 59,

¹ *Untersuchungen zur Morphologie und Systematik der Vögel*. II, Allgemeiner Theil, pp. 1463-1465.

after he has grouped the ostriches together: "A little further afield we should come to the Apteryges, and here attention should be drawn to the ralline tendencies of these abnormal Ratitæ, with all those other peculiar characteristics on which it is not necessary here to dilate at length." Just why the Apteryx should be called "abnormal" more than any other bird living, or extinct, I fail to see. Any puzzling form may seem abnormal when persistent attempts are made to force it into an assemblage of other forms where it does not strictly belong.

Again, Fürbringer in his vertical aspect of the phylogenetic tree of birds has the branch Apterygiformes arise from the main trunk near the rails and far removed from any of the ostriches. In his opinion this Apterygian branch soon forked, however, and gave rise to the two families, Apterygidæ and Dinornithidæ. In his lineal scheme the position given these is in an order Alectoronithes, containing the Apteryges, the Crypturi, the Gallinæ, and the Opisthocomidæ. Many large groups both of land and water birds in this lineal scheme separate them from the ostrich birds, and it is very evident from all this that Fürbringer was of the opinion that the moas and kiwis are but very remotely related to the ostriches, the rheas, the emeus, the cassowaries, or any of the rest of that assemblage.

T. J. Parker commented upon this in the following words:

"The most definite opinion I have met with as to the phylogeny of the Ratitæ is that expressed in the elaborate genealogical tree which illustrates Fürbringer's great work. He ascribes a common origin to the moas and kiwis and to the emeus and cassowaries, but derives his four main groups of Ratitæ — the Struthioniformes, Rheiformes, Casuariformes, and Apterygiformes — separately from a primitive stock.

"Mivart, in his memoir on the axial skeleton of the Ratitæ (*Trans. Zool. Soc.*, Vol. X, 1871), gives no definite opinion as to the phylogeny of the group, but his diagram illustrating the mutual relationships of the various genera seems to indicate his belief in their monophyletic origin. He shows a main stem dividing into two branches; one of these divides again

for *Struthio* and *Rhea*; the other forks a second time, one branch dividing again for *Casuarius* and *Dromæus*, the other for *Dinornis* and *Apteryx*.

"The monophyletic origin of the *Ratitæ* is also supported by Newton, who, in his luminous article, 'Ornithology,' says 'that these forms — moa, kiwi, *emu* and cassowary, *rhea*, and finally ostrich — must have had a common ancestor nearer to them than is the ancestor of any carinate form' seems to need no proof.

"Professor Newton's classification indicates no closer affinity between any of the genera except the *emu* and cassowary, which together constitute his order *Megistanes*; each of the other genera has an order to itself.

"A study of the skull certainly confirms the view that the nearest ally of the *Dinornithidæ* is *Apteryx*, and that the four families of Australasian *Ratitæ* are more nearly related to one another than is either of them to the Asio-African and South-American forms. *Struthio* and *Rhea* differ so much from the Australasian members of the subclass as to lend strong support to Fürbringer's view that they arose separately from a primitive stock; but whether the cassowaries and emus on the one hand and the moas and kiwis on the other had a distinct or a common origin is a very complex question.

"The main difficulty lies in deciding what characters should be considered as of phylogenetic importance and what merely adaptive, but it appears to me that in the following particulars the *emu* and cassowary show an undoubted relationship to the moas.¹

"The general characters of the maxilla, maxillo-palatine, and antrum in both genera.

"The general relations of the vomer, palatines, and pterygoids in both genera.

"The presence of a vestige of the maxillary process of the nasal in *Dromæus*.

"The well-ossified antorbital ankylosed to the descending process of the lacrymal in both genera.

¹ "As my conclusions are based upon a study of the skull, I have omitted all reference to *Æpyornis*, *Dromornis*, *Megalapteryx*, and *Palæocasuarinus*."

"The elevated body of the premaxilla with its distinct pre-narial septum in *Casuarus*.

"Forbes's discovery (*Trans. Nat. Zool. Inst.*, Vol. XXIV, 1891, p. 185) of a dinornithine bird which he calls *Palæocasuarinus* will, if the detailed account of his very interesting researches bears out the opinions expressed in his preliminary note, lend strong support to this view. The tibiae upon which the genus is founded have, as the name implies, a remarkable resemblance to those of the cassowary.

"On the other hand, I know of no character in the skull of *Rhea* by which it definitely approaches the moas, and the presence of a maxillary process to the nasal, the form of the cerebral fossae, and the position of the pneumatic foramen of the quadrate seem the only particulars in which the ostrich comes in any way near them. *Struthio* and *Rhea* are, in fact, sharply separated both from one another and from the Australasian *Ratitæ*, as well by the characters of the bony palate as by those of the pelvis. The characters possessed by them in common with the other *Ratitæ* are of two kinds: ancestral characters, such as the form of the vomer, the basipterygoid processes, and the single-headed quadrate, which, according to the view taken in this paper, are accounted for by the hypothesis of common descent from a group of generalized flying birds or *Proto-Carinatæ*; and adaptive characters, such as those of the sternum, shoulder girdle, and wing, which they share to a greater or less degree with all flightless birds.

"The marked differences between the moas and kiwis are certainly for the most part adaptive; the two families resemble one another in the increased size of the olfactory organ and the reduced size of the eye; but both processes have gone so much further in *Apteryx* that the differences between the two, in this respect alone, give the skulls the appearance of being more widely separated than those of any other two ratite birds. The real affinities underlying these differences are, however, shown by the striking similarity of the bones of the palate in the two forms. The absence of a maxillary antrum in *Apteryx* seems at first sight a difference of great importance, but the fact that this cavity has disappeared or become vestigial in one of the

most specialized genera of the moas seems to indicate that its complete atrophy in the kiwi is simply to be looked upon as an instance of the extreme specialization of that genus."

I have thus fully quoted from T. J. Parker's views upon the relationships of the ostriches and Apteryx for the reason that they are important and useful in the present connection, and that they are entertained by many other naturalists. It must be remembered, however, that these views are drawn up after an examination of the bony skulls alone, or very nearly alone. It must be borne in mind, too, that Marsh endeavored to make ostriches, or ratite birds, out of Hesperornis and Ichthyornis simply because they possessed the ancient form of palate, and that their ilia and ischia possessed free posterior extremities.

I now pass to a consideration of the osteological characters of the Odontoholcæ, the supersuborder to which the Hesperornithidæ belong. It will be necessary to reproduce my observations in order to properly set forth and support my scheme of classification which, as I have already said, will be published in the future.

SUPERSUBORDER III. ODONTOHOLCÆ.

SUBORDER.	SUPERFAMILY.	FAMILIES.
Pygopoformes.	Hesperornithoidea.	Hesperornithidæ. Enaliornithidæ.

Fossil remains of upwards of fifty individuals representing extinct species of the Hesperornithidæ have been taken from the Middle Cretaceous of Kansas and Colorado, where occurred also Ichthyornis (Order II) and its allies. Marsh also described the bones of these great ancestral divers in his *Odontornithes*, and left us a restoration of the skeleton of *Hesperornis regalis*. This was not a difficult task for the reason that nearly perfect skeletons of that form were deposited in the museum of Yale College, and one of these was so complete that it lacked only a very few unimportant bones, as the distal ungual phalanges of two or three of the podal digits.

Hesperornis regalis had a length of about six feet, and an adult specimen when assuming the erect attitude would have had a height of about three feet. The distinguished Scotch

anatomist, D'Arcy W. Thompson, and myself have carefully examined into the osteology of these extinct divers, and have shown that they undoubtedly are among the ancestors of the existing Pygopodes (*vide postea*).

The skull of *Hesperornis* in its general formation resembles closely the skull of such a diver as *Urinator lumme*, but exhibits characters common to many birds belonging to widely separated groups of the age in which it lived. For example, the capacity of the cranial casket was small; the superior articular head of the quadrate bone had but one articular facet; they had teeth in grooves, all the length of either ramus in the lower jaw, but confined to the dentary borders of the maxillaries in the case of the upper. The ramal symphysis was cartilaginous throughout the life of the individual, and consequently each ramus was a separate bone.

According to Marsh, the proximal extremities of the palatines and the distal ends of the pterygoids did not articulate with the basisphenoidal rostrum. The stout basipterygoid processes arose from the body of the basisphenoid, and each one articulated with a facet upon the corresponding pterygoid situated near its proximal end. It had separate vomers. The supraorbital glandular depressions, the holorhinal nostrils, the firmly united intercranial sutures, the form of the quadratojugal, and many other characters, exhibiting but little change in their now living descendants, are each and all characteristic of the Pygopodes. As the teeth do not belong to the skeleton, they require no special description in an article devoted to osteology; be it sufficient to say that they were purely of a reptilian type.

The mandible was long and slender, and "the rami were united at the symphysis in front only by ligament, a feature unknown in modern adult birds. There is an imperfect articulation between the splenial and angular elements, which probably admitted of some motion, and all the other sutures are open, or distinguishable. There was apparently a mandibular foramen. There is a well-marked shallow groove on the outer superior margin of each dentary bone for the reception of the maxillary teeth when the jaws were closed. The angle of the mandible extends backward but a short distance beyond

the articular face for the quadrate, and the extremity is obliquely truncated" (Marsh). *Hesperornis regalis* possessed 49 vertebræ in its vertebral column, or 23 presacrals, 14 sacrals, and 12 caudals. Both in the articular facets of the centra and in other characters they agree with such modern genera as *Urinator* and other divers. In its caudal skeleton this great cretaceous diver was peculiar, the free anterior caudal vertebræ being short, with lofty neural arches and not conspicuous diapophyses, and exhibited an opisthocœlian articulation. Great horizontal expansion characterized the long transverse processes of the mid and posterior caudals, while the last three or four elements of this part of the vertebral chain coössified together in the adult, forming a *flat*, horizontally compressed, pygostylous mass, very different from anything to be found in the form of the terminal piece in the tail of existing Aves. None of the presacral vertebræ united, and none of the caudals possessed zygapophyses. It is very likely that *Hesperornis* used its broad, horizontally flattened tail much as the now-existing beaver among modern mammals employs its paddle-like caudal appendage, — a powerful aid as a propeller and rudder to the aquatic locomotion of this ancient pygopodous fowl.

The sternum in this genus is flat and broad and thin posteriorly. Anteriorly, it is rounded and projecting, while but two shallow notches are to be seen in its xiphoidal margin. The ribs, some of them bearing uncinatè processes, resembled those of the loons, but the shoulder girdle, with its non-united clavicles, was weak and small in character, and the pectoral limb was reduced to a rudimentary humerus.

The pelvis of *Hesperornis* was like the pelvis of our modern loons and grebes, and Marsh observed that it resembles that of *Podiceps*, being very long and narrow, as in that genus, and in other diving birds. He also remarked that the "acetabulum differs from that in all known birds, in being closed internally by bone, except a foramen that perforates the inner wall, as in the crocodiles. The ilium, ischium, and pubis, moreover, have their posterior extremities free and distinct."

The powerful bony framework of the pelvic limbs of this great extinct diver agrees in many characters with the corresponding

parts in the skeleton of the legs in grebes and loons. This has also been noted by Stejneger, and Marsh said in his *Odontornithes* that the "posterior limbs of *Hesperornis regalis* present an admirable example of adaptive structure. The means of locomotion were confined entirely to these extremities, and the life of *Hesperornis* was probably more completely aquatic than that of any known bird. It may fairly be questioned whether it could even be said to walk on land, although some movement on shore was of course a necessity. Considering the posterior limb as a whole, it will be found a nearly perfect piece of machinery for propulsion through the water. Provision was made for a very powerful backward stroke, followed by a quick recovery, with little loss by resistance, a movement quite analogous to the stroke of an oar, feathered on its return.

"Among recent birds, we have, in the genus *Podiceps*, the nearest approach to the legs and feet of *Hesperornis*, and the osseous structure of these parts is essentially the same throughout in the two genera. The muscular system, also, of this member must have been very similar in both. In many respects, however, the bones of the posterior limbs of *Hesperornis* present evidences of a more primitive structure than is seen in any recent diving birds."

The femur was remarkably short and stout, being flattened in the antero-posterior direction. The large, rounded head was supported by a short, strong neck, and excavated above by a pit for the ligamentum teres. Trochanter major was large, and the entire proximal end of the bone possessed an articular surface for the antitrochanter. As in *Urinator*, the shaft was curved, and exhibited strong prominences for muscular insertion. Expanded distally, the outer condyle was the larger of the two, and only a shallow groove divided it from the inner one.

Tibiotarsus was a long, powerful bone, by all odds the biggest one in the skeleton of this bird. It much resembles the same bone of the leg in any of our typical grebes. At its distal end, as in *Podiceps*, there is no osseous bridge in front spanning the longitudinal muscular groove below.

A very large free patella was developed, and it was pierced by a foramen to transmit the tendon of the ambiens muscle, as

in *Sula*. Compressed transversely, it was distinctly triangular upon lateral aspect.

Marsh observed that the fibula of *H. regalis* agreed essentially with that of *Podiceps*, and, as in that genus, the entire skeleton of the limb is non-pneumatic. "In the adult *Hesperornis*, the second, third, and fourth metatarsals are thoroughly coössified into a stout, transversely compressed bone of moderate length, but in most specimens traces of the sutures remain. The fourth metatarsal element so greatly exceeds the other two in size, that it forms by far the greatest part of the entire tarsometatarsal bone.

"The first metatarsal is not coössified with the main shaft of the tarsometatarsal bone, but is a mere remnant, united to the lower half of the second by cartilage [ligament?]."

Different species of *Hesperornis*, as *H. crassipes*, *H. gracilis*, and *H. regalis*, exhibited marked characteristic differences in the various bones of their skeletons. But they were only of specific value.

Of the skeleton of the foot in *H. regalis*, Marsh wrote that the feet of "*Hesperornis* resembled more closely those of the genus *Podiceps* than of any other birds. The number of digits is the same, the number of phalanges in each digit identical, but the proportions of the latter are different and quite peculiar. In *Podiceps*, and the other grebes, the outer toe is the longest, but the middle one almost equals it in length and size, while the second is but slightly smaller. In *Hesperornis*, however, the fourth or outer toe is the dominant one, being three or four times as powerful as the adjoining one, or as the other three combined. Again, the phalanges in *Podiceps* are very elongated and slender, and the terminal ones spatulate, while, in *Hesperornis*, the phalanges are short and thick, with the terminal ones more or less pointed. The phalanges in *Hesperornis* are, in fact, shorter than in most swimming birds, and in their individual proportions remind one of the toe bones of the penguins" (*Odontornithes*, pp. 99 and 100).

Fossil remains of many other birds have been discovered in the cretaceous formation in different parts of America, and a number of these have been described and named by Marsh

and others, but the few bones thus far in the hands of science are too fragmentary to admit of saying to what manner of birds they belonged, much less as to the affinities of the several forms they represent. Others have also come to light in Europe to which the same remarks apply.

As I have already pointed out in the *Journal of Anatomy* (London, April, 1892, p. 202), I consider all the species of the genus *Hesperornis* as having belonged to a family *Hesperornithidæ*, and this family may possibly have been an offshoot of a superfamily, the *Hesperornithoidea*, which contained forms possessing the power of flight; and from these latter our present *Pygopodes* have descended, while the offshoot-genus *Hesperornis* died out during the cretaceous time, and left no direct descendants.

What I have said elsewhere in regard to the characters in the skeletons of these ancient birds not possessed by their representatives of the present age, applies also to *Hesperornis*. For example, the structure of the palate, the extremities of the pelvic bones being free, and so forth, are derived from their reptile ancestors just as the ostriches derived theirs, and the last named are now existing forms that have carried them down.

Family: ENALIORNITHIDÆ.

Of the remains of the fossil *Enaliornis* I know nothing beyond what I have learned from reading. Lydekker, in the article "Fossil Birds," in Newton's *Dictionary of Birds* (p. 280), has said, "In 1858 Barrett discovered in the Upper Greensand of Cambridgeshire remains described by Professor Seeley in 1866 (*Ann. and Mag. Nat. Hist.*, Ser. 3, Vol. XVIII, p. 100) under the preoccupied name *Pelagornis*, but in 1867 renamed *Enaliornis* ('Index to Aves and Reptilia, Camb. Mus.,' *Quart. Journ. Geol. Soc.*, Vol. XXXII, p. 509). These indicate a bird apparently allied to *Colymbus*, and not improbably to *Hesperornis*."

Fürbringer fully discusses what is known of the *Enaliornithidæ* (pp. 1152, 1153) and is satisfied of the relation of *Enaliornis* to the extinct toothed loon, *Hesperornis*, as well as to the various existing *Pygopodes*, and classifies it accordingly.

HATS FROM THE NOOTKA SOUND REGION.

CHARLES C. WILLOUGHBY.

IN the early days of the New England whaling industry the sailors brought back as mementoes many valuable ethnological objects from the Pacific islands and the northwestern coast of America. Much of this material found its way into the cabinets of the older societies of Boston, Salem, and other New England towns.

The Peabody Museum of Harvard University has acquired a number of these old ethnological collections, either whole or in part, including that of the American Antiquarian Society, the Boston Athenæum, the Boston Marine Society, the Massachusetts Historical Society, and the Boston Museum. The few objects in these collections from the northwest coast are of great value, illustrating as some of them do phases of the arts which have become extinct or much modified.

Among the objects received from these societies are eight hats of the type illustrated upon Plate I, a style of head covering very rarely found in museums or private collections. It is probable that this form of hat originated among the southern Wakashan tribes, probably the Nootkas, although Lewis and Clark found them on the lower Columbia in 1605 at Fort Clatsop and thus described them (p. 768).¹

"We gave a fish-hook also in exchange for one of their hats. These hats are made of cedar-bark and bear grass interwoven together in the form of a European hat with a small brim of about two inches and a high crown widening upwards. They are light, ornamented with various colors and figures. . . . These hats form a small article of traffic with the whites, and their manufacture is one of the best exertions of Indian industry." And again on page 777, writing of the dress of the women: "The only covering for their head is a hat made of bear grass

¹ *History of Lewis and Clark Expedition*. Edited by Elliott Coues. Vol. ii.

and the bark of cedar interwoven in a cone form with a knob of the same shape at the top. It has no brim, but is held on the head by a string passing under the chin and tied to a small rim inside the hat. The colors are generally black and white only, and these are made into squares, triangles, and sometimes rude figures of canoes and seamen harpooning whales."

When Captain Cook visited Vancouver Island during his famous voyage of 1776-1780, he found the same form of head covering worn by the Indians of Nootka Sound, and on one of the plates in the second volume of the octavo edition (London, 1784) is a drawing of a woman with a hat of this form. This is reproduced at *b*, Plate I.

Cook writes (p. 242) that the "natives wear a hat like a truncated cone or a flower pot, made of very fine matting, ornamented with a round knob or a bunch of leather tassels, having a string passing under the chin to prevent it blowing off," and on page 266, "The whole process of their whale-fishery has been represented . . . on the caps they wear."

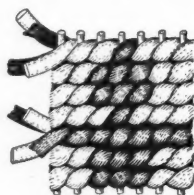


FIG. 1.—Detail of weaving.

It is probable that this kind of head covering was prevalent from Nootka Sound to the Columbia River, at least in the coast region.

The peculiar manner in which the cedar-bark strips and the grass spires are manipulated (Fig. 1) to form the design is seen in the modern basketry of the Skokomish, and is probably found in other basketry of the Puget Sound region. It occurs in the basketry of the Hooper valley and other northern California Indians, as will be seen on examination of the basket caps and old cooking bowls made from shredded pine roots and squaw grass. This squaw grass of the Hupa and Shasta Indians seems to be identical with the bear grass of Lewis and Clark.

The conventional representation of the canoe shown in the whaling scenes upon Plate I is found upon the modern basketry of the Makah Indian of Cape Flattery, Washington, the southernmost of the Wakashan (Nootka) family.

The hats in the Peabody Museum are all of twined weaving, and are made principally of cedar bark and grass spires. The

construction is double, as shown in the cross-section (Fig. 2). Each headpiece consists really of two hats, an inner and an outer one, joined at the rim, the last few pairs of twisted woof elements of the outer hat enclosing also the ends of the warp of the inner. The inner hat, or lining, is coarsely but neatly woven of cedar bark, and only in one specimen (*a*, Plate I) is there a knob at the top of the lining corresponding to that of the outer hat. Upon the under side at about three inches from the rim each warp element is doubled upon itself, forming a loop about three-fourths of an inch long. Through these loops is run a strong double cord of Indian hemp. The loops are bound together by twined weaving, and form an inner rim edged with the cord of hemp, which fits the head snugly. To this is fastened the thong which passes beneath the chin of the wearer.

The exterior or outer hat is woven principally of grass spires and cedar bark. In most of the specimens a narrow strip below the knob is made of fine cedar roots. The warp appears to be formed of split roots, and is fine and strong. The grass of the woof was originally an ivory white, the selected cedar bark used in conjunction with it being usually stained a dark brown or black.



FIG. 2. — Cross-section showing double construction of hat.

Each strand of the twisted pair of woof elements forming the design is composed of a grass spire and a strip of cedar bark of the same width laid side by side, the strand thus formed being white upon one side and black upon the other. These double strands are used not only where figures appear, but throughout the groundwork of the design as well. The figures are principally black upon a white ground. In forming them the strands are simply reversed, the black sides which were concealed beneath the grass spires in the white background being carried outward, as shown in Fig. 1. In some of the specimens the knob at the top is woven separately and afterwards joined to the hat. In the hat illustrated at *f*, Plate I, a small wooden hoop is placed within the knob to preserve its

shape. The materials are selected and prepared with great care. The designs are spirited and well executed, and the technique is of the highest order.

The principal design upon all but one of the hats represents the chase of the orca or killer whale. It has been harpooned, and the harpoon line with attached floats is trailing behind. A man standing in the bow of a canoe is about to dispatch the animal with a lance. Other canoes, apparently empty, fill out the design. The Indians of Nootka Sound and vicinity, as well as the tribes to the southward, hunted the orca, but the animal was held sacred by the northern coast tribes and was never hunted by them.

A very different design is shown upon the hat illustrated at *f*, Plate I. The mythical bird is represented four times, twice by itself near the brim and upon opposite sides, once hovering just above an orca, and again with the whale in its talons. A peculiar and characteristic feature is the life line, extending from the beak to the heart, which is represented by a light spot. There are two small, winglike projections back of this spot on each of the birds, which remind one forcibly of the tufts of feathers above the neck membrane of the pinnated grouse. A similar mythical design is etched upon an Eskimo harpoon rest carved in ivory, illustrated on Plate LXXII of the National Museum Report for 1895. In this drawing the bird is twice represented hovering over the whale, and twice with the whale in its talons.

There are doubtless many valuable and rare ethnological objects still in the families of the old whalers in the eastern and middle states. These should be deposited for safe keeping in museums of standing, where they would be preserved for all time, and be accessible to students. Otherwise their destruction or loss is inevitable.

PEABODY MUSEUM OF
AMERICAN ARCHAEOLOGY AND ETHNOLOGY,
CAMBRIDGE, MASS.

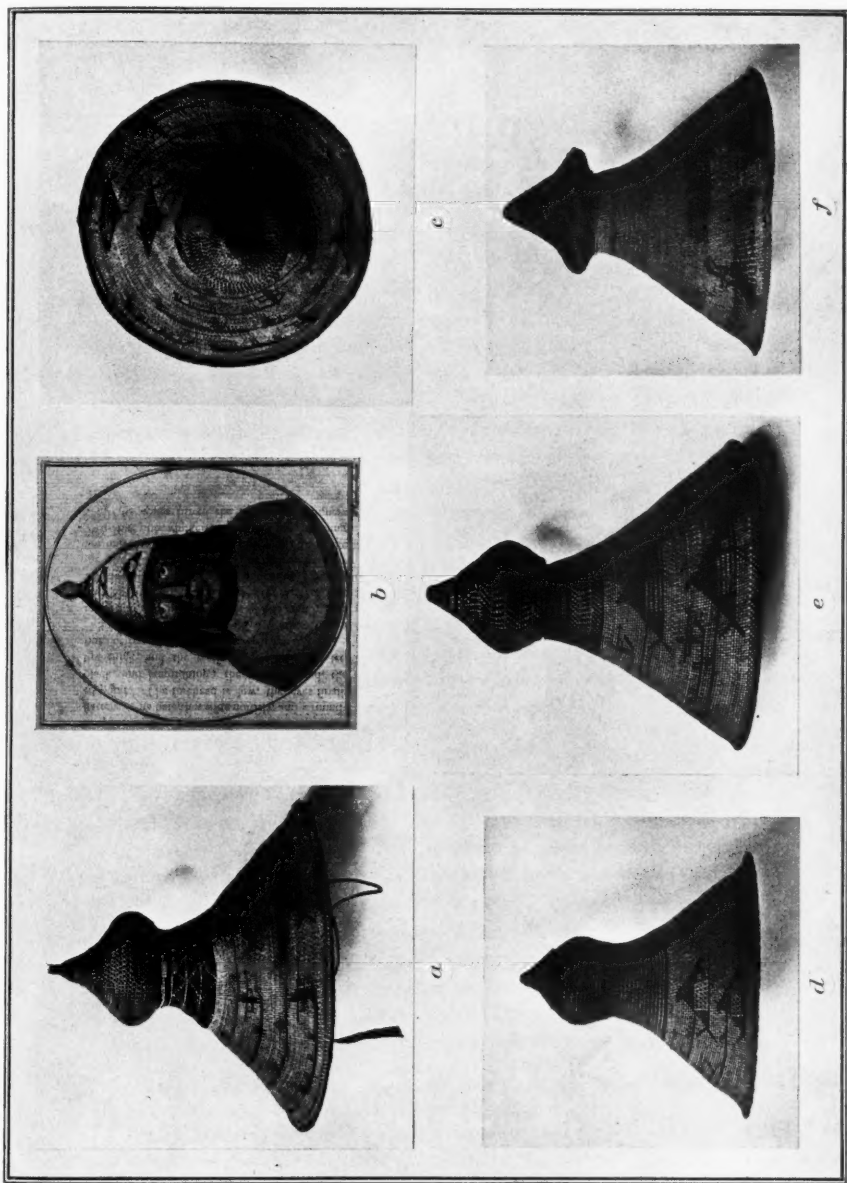


PLATE I.—*a, d, e, f*, hats from the Nootka Sound region; *c*, same as *e*; *b*, woman of Nootka Sound, from "Cook's Voyages."



NOTES AND LITERATURE.

GENERAL BIOLOGY.

Morgan's "Regeneration."¹—Students of experimental morphology have been done a real service by the author of this book. He has brought together and classified in an orderly way practically all that is known about the subject of regeneration in animals. A not inconsiderable part of this knowledge has been contributed by Professor Morgan himself or by his pupils. The author is hostile to "the hypothesis of preformed nuclear germs" and to "the theory of natural selection as applied to regeneration," but shows no spirit of unfairness. His work is both careful and comprehensive. It includes chapters on the early and justly famous experiments made by Trembly, Bonnet, and Spallanzani; on the external factors of regeneration; on the internal factors of regeneration; on regeneration in plants; on regeneration and liability to injury; on self-division, budding, etc.; on animal grafting; on relation to regeneration of the "germ-layer theory" and "the law of biogenesis"; on regeneration in egg and embryo; theories of development; theories of regeneration; etc. It is a work both of merit and of permanent value, well worthy of a place in the excellent series of biological books in which it is published.

W. E. C.

Inheritance of Acquired Characters.—One of the most interesting additions to the series *Scientia* is Costantin's² "L'hérédité acquise." In a very brief space the author gives a readable account of Weismann's germ plasm theory and of the changes that it has undergone. Then follow chapters on heredity in asexual reproduction, on artificial selection, and on certain objections to the influence of the environment. The very interesting subject of hereditary diseases is well treated, and the little volume ends with a chapter on germinal selection. While in no sense an original contribution to the subject, the book forms an excellent introduction for the beginner or even the layman.

¹ Morgan, T. H. *Regeneration*. Columbia University Biological Series, vol. vii. New York, Macmillan, 1902. 8vo, xii + 316 pp., 66 figs.

² Costantin, J. *L'hérédité acquise*, *Scientia*, Biologie, No. 12. Paris, Carré et Naud, 1902. 86 pp.

ZOOLOGY.

The Habits of Fishes.¹ — The author contends that : Physiologically, fresh water (and probably all) fishes fall into two groups, — those which spawn in warming water and those which spawn in cooling water, and the cause of spawning is the temperature trend in *one* direction ; structurally similar forms tend strongly to sustain similar relations to the temperature curve, *i.e.*, to spawn either all on its ascending, or all on its descending limb ; in at least some cases apparent exceptions can be harmonized with the law ; for a given species the temperature relations which determine its migrations, and probably also its geographical distribution, are the same as those which determine its spawning. These facts demonstrate the presence of a temperature-responsive nerve-mechanism, which is a character of prime importance, entitled to at least superfamily rank ; its existence explains *why* with in-cooling spawning,² is (and must be) associated to-cooler migration² and boreal distribution (and with in-warming spawning, to-warmer migration and austral distribution) ; by a working backwards from the time of most successful hatching, the time of spawning has been determined via natural selection ; that time so fixed, by a further working backward natural selection has determined the time of precedent migration ; there are, *de facto*, beach spawners ; in type of egg the beach spawners agree with the fresh water, and differ from the pelagic, forms, and this difference explains why species of pelagic genera are so rare in fresh water, and beach spawners are now uncommon, they having mostly become anadromes ; for having attained to a seek-the-beach impulse, the conditions on the beach were such that, natural selection not opposing, the beach spawners must, through the mere continued action of the temperature-responsive mechanism, have been led, step by step, into the forming streams of a rising continent ; and in the streams the necessary accessory instincts have been evolved, all in accordance with accepted biological principles. The most important generalizations are : Dynamically, fishes fall into two great groups according as they are stimulated to migrate geographically, to migrate for spawning, and to spawn, by warming water, or by cooling water ; and this dynamic factor necessarily involves a northern limit to the range of

¹ Gurley, R. R. *Amer. Journ. Psychol.*, vol. xiii (July, 1902), pp. 408-425.

² *In-cooling spawning*, spawning in cooling water ; *to-cooler migration*, migration from warmer water to cooler.

the species of the first group, and a southern limit to that of the species of the second group, the limit in each case being the point where the spawning temperature disappears; and the factor which has determined whether a given species was to remain a marine, or to become a fresh water form, has been the egg type. W. C. K.

Development of the Face. — As a contribution to the study of the external form of developing vertebrates, Rabl¹ has published eight quarto lithographic plates illustrating the development of the face in mammals. The species chosen are the rabbit, the pig, and the human being; and of the first as many as seventeen stages are shown. Each stage is illustrated as a rule by three views of the head: full face, profile, and three-quarters. The material from which the drawings were made was selected with as much care as the circumstances would permit, and fixed in picro-sublimate or in platinic chloride and sublimate. It was found advantageous for surface views to stain the embryos in Grenacher's alcoholic borax carmine. The surface configuration of such specimens has been rendered in the figures with exquisite fineness of touch, reflecting great credit alike on the draughtsman and the lithographer. The figures are not marred by descriptive lettering, but a sheet of semi-transparent paper is attached to each plate and bears the outlines of the figures and the lettering. The text is a running description of the material. Problems of external morphology are not discussed in it, though the author hopes that the work may afford a basis for the study of the laws governing the development of external form. Three more parts are to be issued covering presumably the other groups of vertebrates, and the whole will constitute an indispensable guide not only to the specialist in the development of the face, but to embryologists in general. Great credit is due to the author and to the publisher for the production of so beautiful a piece of work, and also to the Imperial Academy of Sciences in Vienna for its generous support. P.

Pectoral Appendages of Birds. — The latest published part of Fürbringer's² exhaustive studies on the comparative anatomy of the

¹ Rabl. C. *Die Entwicklung des Gesichtes*. Heft 1, Das Gesicht der Säugethiere, I. Leipzig, W. Englemann, 1902. vi + 21 pp., 8 pls.

² Fürbringer, M. Zur vergleichenden Anatomie des Brustschulterapparates und der Schultermuskeln. *Jenaische Zeitschrift für Naturwissenschaft*, Bd. xxxvi (1902), pp. 289-736, Taf. XVIII-XXII.

pectoral region of vertebrates contains an account of the bones, nerves, and muscles of the breast, shoulder, and wings of birds. In addition to the admirably clear descriptions of the anatomy of these organs, this part is of special interest in that it contains a full discussion of the systematic relations of the orders and families of birds as well as an account of the relations of birds to other vertebrates. The diphyletic origin of the birds as represented by the Ratitæ and Carinatæ is regarded as an untenable assumption by Fürbringer, who argues for the racial unity of the whole group. From this standpoint the Ratitæ represent either a primitive stock from which the Carinatæ have sprung or, as Fürbringer believes, a degenerate assemblage derived from the Carinæ. The author further believes that birds have had their origin from none of the known orders of reptiles, but from an ancient stock among the very oldest reptiles and of which at present no remains are known. P.

Spiders of the United States.¹ — As the title indicates, this book was written to meet a popular need. The first part, which is given up to a short introduction on structure, collecting, and habits, might very well have been enlarged. The remainder of the book is taken up by a systematic account of spiders.

About two hundred of the common species of the eastern United States are described. The descriptions are short, often very short. The illustrations are excellent. Each species has one and often four figures to show the characteristic parts and markings. The common round web species that are found in similar places are described together. The photographs of the webs are especially good, and from them the whole process of web making can be followed.

The value of the book would have been increased for amateurs by reference to a few of the popular books on spiders, and for more advanced readers by the authorities of the species.

BOTANY.

The Yuccæ.² — At a time when systematic activity is preponderatingly segregative and the tendency to publish species separately

¹ Emerton, James H. *The Common Spiders of the United States*. Boston, Ginn & Co., 1902. 8vo, xviii + 225 pp., 501 figs.

² Trelease, William. *Thirteenth Annual Report of the Missouri Botanical Garden*, July, 1902.

has become excessive, every piece of monographic work based upon prolonged study of a particular group and passing mature and connected judgment upon all its species is a welcome addition to scientific literature. This is especially true of Professor Trelease's work on the Yuccæ from the fact that it treats a group of natural difficulty, in which, as in the case of the palms, cycads, Cactaceæ, and other large and succulent plants, ordinary herbarium methods are least effective and must to a great extent be supplemented by the slower and far more difficult process of visiting the growing plants in their native habitats or cultivating fresh material. The paper under consideration is an octavo of 133 pages, copiously and excellently illustrated by 100 plates, the latter being chiefly halftones from photographs. The work presents "the principal conclusions reached in an intermittent herbarium, garden, and field study extending over the last sixteen years, in the course of which nearly all of the spontaneous species have been examined and photographed in their native homes."

The author divides the Yuccæ into five genera. The genus *Yucca* is confined to those species which possess globose or broadly campanulate flowers with a thin polyphyllous perianth and a short thick or obsolete style. From *Yucca*, which includes twenty-seven species and may be regarded as the central and typical genus of the group, *Hesperaloe*, with two species, is distinguished by its narrow perianth, *Hesperoyucca* (monotypic) by its filiform style, *Clistoyucca* (monotypic) by its thickened perianth, and *Samuela*, with two species, by its gamophyllous perianth. *Yucca* is divided upon the nature of the fruit and seed into three sections: *Chænoyucca* (the filamentosa group), *Heteroyucca* (the gloriosa group), and *Sarcoyucca* (the baccata group).

Under each species and variety exhaustive bibliography and synonymy are given. These cover not merely the botanical treatment of the plants concerned, but also the far more involved and vague horticultural references, and the frequency with which the mark of interrogation accompanies the citation of synonymy is certainly significant. Here an energetic specialist, exceptionally situated for the thorough investigation of his group and engaged in the revision of not over thirty or forty species, finds himself, even after some sixteen years' effort at the elucidation of his group, obliged to use no less than ten question marks in stating the synonymy of a single species. A few of these doubts refer, as might be supposed, to old and vague characterizations published by the earlier authors, who

did not realize the complexity of the genera with which they were dealing; but the majority relate to the botanico-horticultural species and varieties published by authors who are still living. The great indefiniteness which surrounds plants of this sort may well raise the question, whether a botanist who undertakes either voluntarily or at the solicitation of some nurseryman to give a scientific name and botanical description to some cultivated plant of which he knows neither the country, habitat, natural origin, nor degree of permanence, is doing more to advance or to block the progress of botanical classification. Happily this sort of work is relatively rare in America. In Europe, however, some botanists of rather high standing seem ever ready to undertake this, the lowest type of taxonomic activity, especially in the already much abused groups of succulents. Certainly *Yucca* has had its share of such botanico-horticultural treatment, and it is therefore a pleasure to see the genus subjected to a critical and scientific revision based so largely upon study of the plants in their natural state.

It is to be regretted that space was not found in Professor Trelease's monograph for a more complete citation of herbarium specimens, especially those of standard sets, for no feature of monographic work gives more definiteness and permanent influence to a revision, since by fixing uniform standards in reference collections throughout the world it is of the greatest service in bringing about harmony in classification.

The paper closes with a *résumé* of the economic uses, phylogeny, and ecology of the *Yuccæ*. A series of outline maps is also introduced to show the distribution of the forms known to occur in nature.

B. L. R.

The International Catalogue.¹ — The first part of the long-expected Royal Society's catalogue of current botanical literature, though dated in May and with the MSS. completed in January last, did not reach the libraries of this country until the middle of August. Aside from general prefatory matter, this first part contains the well-known classification of botany adopted by the Council, and an alphabetical index to the same, in English, French, German, and Italian, followed by a topographical classification in the same languages. The catalogue proper consists of an authors' catalogue,

¹ *The International Catalogue of Scientific Literature*, first annual issue. M. Botany. Published for the International Council by the Royal Society of London. Vol. i, pt. i. 1902.

each entry marked with a classification symbol and secondary reference marks. This authors' list, occupying eighty-four double column pages, is followed by a subject catalogue with alphabetical arrangement of authors under each principal heading. In the systematic part, each main group is provided with an index to the contained new genera and species. The number closes with a list of the journals abstracted, with abbreviated titles. T.

Notes. — The principal articles of the *Botanical Gazette* for August are: Heald, "The Electrical Conductivity of Plant Juices"; McCallum, "Nature of the Stimulus causing the Change of Form and Structure in *Proserpinaca palustris*"; Schneider, "*Rhizobia mutabile* in Artificial Culture Media"; Nelson, "Notes on Certain Species of *Antennaria*"; Reed, "A Survey of the Huron River Valley"; Ramaley, "The Trichome Structures of *Erodium cicutarium*"; and Copeland, "Two Fern Monstrosities."

The *Bulletin of the Torrey Botanical Club* for July contains the following articles: Torrey, "Cytological Changes accompanying the Secretion of Diastase"; Banker, "Historical Review of the Proposed Genera of the Hydnaceæ"; Shear, "Mycological Notes and New Species"; Durand, "Studies in North American Discomycetes: II, Some New or Noteworthy Species from Central and Western New York"; Lamson-Scribner and Merrill, "New or Noteworthy North American Grasses"; Eastwood, "New Species of *Nemophila* from the Pacific Coast"; Britton, E. G., "*Trichomanes radicans*"; Berry, "*Liriodendron celakovskii*."

The *Plant World* for July contains the following principal articles: Parish, "Through Desert and Mountain in Southern California"; Idelette Carpenter, "The Protection of Native Plants"; Pollard, "Plants used for Cuban Confectionery"; Hay, "A New Station for the Gray Polypody"; and eight pages of Mr. Pollard's "Families of Flowering Plants, — from Hydrophyllaceæ to Solanaceæ."

The first part of Vol. LIV of the *Proceedings of the Academy of Natural Sciences of Philadelphia* contains the following botanical articles: Meehan, "Contributions to the Life-History of Plants, No. XVI," and Harshberger, "The Germination of the Seeds of *Carapa guianensis*." An article by Montgomery, "On Phylogenetic Classification," though written principally from the zoological point of view, deals with questions of the greatest interest to botanists.

Several small papers of taxonomic interest were issued under date of August 6, as signatures of the *Proceedings of the Biological Society of Washington*.

Rhodora for July, in addition to a large number of notes of local interest, contains an article by Dr. Robinson on the protection of our native flora, descriptions of several new grasses, by Merrill, and a protest by Fernald against the substitution of *Washingtonia* for *Osmorhiza*, apropos of the discovery of *Osmorhiza obtusa* in Labrador.

The August number of *Rhodora* contains the following articles: Fernald, "*Taraxacum palustre* in America"; Davenport, "Notes on New England Ferns"; Sargent, "Additions to the Flora of Massachusetts"; Williams, "Noteworthy Carices at Sudbury, Massachusetts"; Shaw, "*Carex aurea* in Connecticut"; Norton, "New Stations for *Peltranda* and *Conopholis*"; Chamberlain, "*Aulacomnium heterostichum* in Maine"; Lee, "*Aquilegia canadensis* var. *flaviflora* in Maine"; Rich, "*Juncus torreyi* and *Ellisia nyctelea* in Massachusetts."

Torreyia for August contains the following articles: Lloyd, "Vivipary in *Podocarpus*"; Earle, "A Key to the North American Species of *Russula*"; Howe, "A Note on the Vitality of the Spores of *Marsilea*"; Abrams, "A New *Hemizonia* from California"; Britton, "An Undescribed Species of *Hydrophyllum*"; Eggert, "Notes on *Verbena*"; Shinn, "*Lunularia cruciata* in Fruit."

Recent articles not likely to meet the eye of most botanists are: Lemmon, "Conifers of the Pacific Slope," in *Sierra Club Bulletin*, Vol. IV, No. 2, and Lemmon, "Oaks of Pacific Slope," in *Transactions of Pacific States Floral Congress*.

Vol. III, Part IV, of J. Medley Wood's *Natal Plants*, concluding that volume, has recently been issued from the press of Bennett & Davis, of Durban. Each volume contains one hundred habit and detail plates with appropriate text.

Fascicle 6 of Vol. I of Mr. Howell's *Flora of Northwest America*, comprising pages 563 to 666, completes Plantaginaceæ and reaches into Pontederiaceæ.

The results of studies on relations of plants to electricity made at the Harvard botanic garden, are given in a paper by Plowman in the *American Journal of Science* for August.

The effects of a tornado in the Victoria (Kamerun) botanical garden are noted by Preuss in *Der Tropenpflanzer* for July.

In *Country Life in America* for September, H. A. Doty has an article on the Pollination of *Asclepias*, illustrated by a number of low-power photo-micrographs.

Messrs. Gardiner and Hill discuss the histology of the endosperm during germination in *Tamus* and *Galium*, in the *Proceedings of the Cambridge Philosophical Society* of August 13.

A leaf section of *Tecoma*, showing the sunken nectar gland, is published in the *Gardeners' Chronicle* for July 19.

A useful directory of agricultural experiment stations in foreign countries is published as *Bulletin No. 112* of the Office of Experiment Stations, U. S. Department of Agriculture.

The tropical growth of epiphytes, which proves detrimental to the growth of cacao and lime trees, is discussed by Howard in the *West Indian Bulletin*, Vol. III, No. 2.

An article by Fawcett on the banana industry in Jamaica is contained in No. 2 of the current volume of the *West Indian Bulletin*, which also has an article by Hart on the preparation of essential oils in the West Indies, and an article by Freeman on the aloe industry of Barbados.

Country Life in America is publishing a series of articles on the making of a country home, which, like everything else published in that journal, are beautifully and instructively illustrated.

The growth of the famous St. Michaels pineapple is described by Bernegau in *Der Tropenpflanzer* for August.

Consul Ragsdale reports on Ginseng in China, in *Advance Sheets of Consular Reports* of August 23.

An article on "Coffee; Its History and Commerce," by Marshall, is contained in the *American Journal of Pharmacy* for August.

The *World's Work* for September contains an interesting article by Howard on breeding new kinds of corn.

A comparative anatomical study of water lilies, by Chiffot, is published as fascicle 10 of the *Annales de l'Université de Lyon*.

As a reprint from the *Annals of the Carnegie Museum*, Mr. Ashe issues descriptions of a number of new Pennsylvanian species of *Cratægus*.

The opening double number of Vol. XVI of the *Annales des Sciences Naturelles, Botanique*, is entirely occupied with ovule studies of *Rosaceæ*.

A paper on the root tubercles of *Medicago* and other leguminous plants, by Professor Peirce, constitutes No. 10 of the current volume of botanical *Proceedings of the California Academy of Sciences*.

A Revision of the Japanese Umbelliferæ, by Yabe, is contained in Vol. XVI of the *Journal of the College of Science* of the Tokyo University.

The first part of Abbé Lévillé's Monograph of the Genus *Onothera*, illustrated with numerous photograms from herbarium sheets, and anatomical and other details, has been issued by the author at Le Mans. Two other fascicles are promised for the early part of 1903 and 1904, respectively.

The alders of Japan are revised by Matsumura in Vol. XVI of the *Journal of the College of Science* of the Tokyo University.

Habit and bark photograms of *Pinus inops* are published by Professor Rothreck in *Forest Leaves* for August.

The *Fern Bulletin* for July contains the following principal articles: Anthony, "Fern Hunting in Nassau"; Watkins, "Some Ferns of the Sierra Nevada Range"; Eaton, "The Genus *Equisetum* in North America"; Gilbert, "Georgia Ferns"; Clute, "*Botrychium ternatum* and *obliquum*"; and a continuation of Clute's list of fernworts collected in Jamaica.

The genus *Selaginella* receives a considerable addition in new species in a paper by Hieronymus, in *Hedwigia* for August.

An extensive and largely illustrated paper on the mosses of Alaska, by Cardot and Thériot, forms a brochure of Vol. IV of the *Proceedings of the Washington Academy of Sciences*, issued July 31. The paper is based on collections made by members of the Harriman Alaska Expedition in 1899, and is No. 29 of the "Papers from the Harriman Alaska Expedition."

The coralline algæ of Japan form the subject of a largely illustrated paper by Yendo, in Vol. XVI of the *Journal of the College of Science* of the Tokyo University.

No. 3 of the *University of Maine Studies* consists of a preliminary list of Maine fungi, by Ricker.

Bulletin No. 96 of the Kentucky Experiment Station is in part devoted to poisonous and edible mushrooms, illustrated by a number of good photograms.

Torrendia, a gasteromycetous *Amanitopsis*, is described and figured by Bresadola in fascicle 2 of the current volume of *Atti della I. R. Accademia degli Aggiati in Rovereto*.

CORRESPONDENCE.

To the Editor of the American Naturalist.

SIR : — By an unfortunate mistake in my "Lamarck, the Founder of Evolution," it is stated on p. 56 that he died December 28, 1829, whereas the exact date is December 18, 1829. Therefore, on p. 56, line 3 from the bottom, for December 28, read December 18; and on p. 57, line 5, for December 30, read December 20.

The following is a copy of the *Acte de décès* :

VILLE DE PARIS — Année 1829. L'an mil huit cent vingt-neuf, le dix-huit décembre, est décédé à Paris, au Jardin du Roi, JEAN BAPTISTE PIERRE ANTOINE DE MONET DE LAMARCK, membre de l'Institut, âgé de quatre-vingt-cinq ans, veuf.

Le membre de la Commission,

Signé : DURANTON.

Also on p. 9, line 15, for "father" read "grandfather."

A. S. PACKARD.

PUBLICATIONS RECEIVED.

BALDWIN, J. M. Development and Evolution, including Psychological Evolution, Evolution by Orthoplasia, and the Theory of Genetic Modes. New York, The Macmillan Company, 1902. 8vo, xvi + 395 pp. \$2.60. — JORDAN, D. S. The Blood of the Nation: a Study of the Decay of Races through the Survival of the Unfit. Boston, American Unitarian Association, 1902. 82 pp. — KEYSER, LEANDER. Birds of the Rockies, with a Complete Check List of Colorado Birds. Chicago, A. C. McClurg & Co., 1902. 8vo, ix + 355 pp., 8 pls. and text-figs. — MELL, P. H. Biological Laboratory Methods. New York, The Macmillan Company, 1902. 8vo, xiii + 321 pp., 123 figs. \$1.60. — VERWORN, MAX. Die Biogenhypothese. Eine kritisch-experimentelle Studie über die Vorgänge in der lebendigen Substanz. Jena, Fischer, 1902. 8vo, iv + 114 pp. 2.50 marks.

ALEXANDER, A. B. Notes on the Boats, Apparatus, and Fishing Methods employed by the Natives of the South Sea Islands, and Results of Fishing Trials by the *Albatross*. *Rept. U. S. Fish Com. for 1901*. Pp. 741-829, Pls. XXX-XXXVII. Text-figs. — ALLEN, J. A. Mammal Names proposed by Oken in his Lehrbuch der Zoologie. *Bull. Amer. Mus. Nat. Hist.* Vol. xvi, pp. 373-379. — ARECHAVALETA, J. Contribución al conocimiento de la Flora Uruguaya: varias especies nuevas y otras poco conocidas. *Ann. Mus. Nac. Montevideo*, 1902. 24 pp., 8 figs. — BANKS, N. A List of Spiders collected in Arizona by Messrs. Schwarz and Barber during the Summer of 1901. *Proc. U. S. Nat. Mus.* Vol. xxv, pp. 211-221, Pl. VII. — BARBER, C. M. Notes on Little-Known Mexican Mammals and Species apparently not recorded from the Territory. *Proc. Biol. Soc., Wash.* Vol. xv, pp. 191-193. — BOULE, M. *Machairodus* Européens. *Bull. Soc. Geol., France*, Sér. 4. Tome i, pp. 551-573. 17 figs. — BOULE, M. Les créatures géantes d'autrefois. *Rev. Gen. Sci.*, October, 1902. 46 pp., 30 figs. — BOULE, M. Les volcans de la France Centrale. *Livre Guide VIII Cong. Internat. Geol.* 36 pp., 3 pls., 28 figs. — BOULE, M. Étude paléontologique et archéologique sur la station paléolithique du Lac Karâr (Algerie). *L'Anthropologie*. Tome xi, pp. 1-21, Pls. I-II. 24 text-figs. — BOULE, M. Équidés fossiles. *Bull. Soc. Geol., France*, Sér. 3. Tome xxvii, pp. 531-542. 22 figs. — BOULE, M. L'abri sous Roche du Rond près Sainte-Arcons-D'allier (Haute Loire). *L'Anthropologie*. Tome x, pp. 385-396. 23 figs. — BOULE, M. Compte-Rendu de l'excursion dans le Massif Central. *Compt. Rend. VIII Cong. Internat. Geol.* 5 pp. — BOULE, M. La géologie et la paléontologie de Madagascar dans l'état actuel de nos connaissances. *Compt. Rend. VIII Cong. Internat. Geol.* 16 pp., 1 map. — CALKINS, G. N. Marine Protozoa from Woods Hole. *Bull. U. S. Fish Com. for 1901*. Pp. 413-468. 69 figs. — CLARK, H. L. Papers from the Hopkins Stanford Galapagos Expedition, 1898-1899. XII. Echinodermata. *Proc. Wash. Acad. Sci.* Vol. iv, pp. 521-531. — DOUGLASS, EARL. Fossil Mammalia of the White River Beds of Montana. *Trans. Amer. Phil. Soc.*, N.S. Vol. xx, pp. 237-279, Pl. IX. — DUERDEN, J. E. Boring Algae as Agents in the Disintegration of Corals. *Bull. Amer. Mus. Nat. Hist.* Vol. xvi, pp. 323-332, Pl. XXXII. — DUERDEN, J. E. The Morphology of the Madreporaria. II. Increase of the Mesenteries

- in Madreporia beyond the Protocnemic Stage. *Ann. Mag. Nat. Hist.*, Ser. 7. Vol. x, pp. 96-115. 13 figs. — EIGENMANN, C. H. The Eyes of *Rhinema Florida*. *Proc. Wash. Acad. Sci.* Vol. iv, pp. 533-548, Pls. XXXII-XXXIV. — GOETTE, A. *Lehrbuch der Zoologie*. Leipzig, Engelmann, 1902. 8vo, xii + 504 pp., 512 figs. 12 marks. — HALL, W. L., and SCHRENK, H. VON. The Hardy Catalpa. *Bull. U. S. Dept. Agr., Bureau of Forestry*, No. 37. 58 pp., 30 pls. — HAY, W. P. Observations on the Crustacean Fauna of Nickajack Cave, Tennessee and vicinity. *Proc. U. S. Nat. Mus.* Vol. xxv, pp. 417-439. 8 figs. — HOVEY, E. O. Martinique and St. Vincent: a Preliminary Report upon the Eruptions of 1902. *Bull. Amer. Mus. Nat. Hist.* Vol. xvi, pp. 333-372, Pls. XXXIII-LI. — JOHNSON, R. H. Axial Bifurcation in Snakes. *Trans. Wis. Acad. Sci.* Vol. xiii, pp. 523-538, Pls. XXXI-XXXVIII. — JORDAN, D. S., and FOWLER, H. W. A Review of the Ophidioid Fishes of Japan. *Proc. U. S. Nat. Mus.* Vol. xxv, pp. 743-766. 5 figs. — JORDAN, D. S., and STARKS, E. C. A Review of the Hemibranchiate Fishes of Japan. *Proc. U. S. Nat. Mus.* Vol. xxvi, pp. 57-73. 3 figs. — KELLOGG, V. L., and KUWANA, S. S. Papers from the Hopkins Stanford Galapagos Expedition, 1898-1899. X. Entomological Results: Mallophaga from Birds. *Proc. Wash. Acad. Sci.* Vol. iv, pp. 457-499, Pls. XXVIII-XXXI. — KISHINOUE, K. Some New Scyphomedusæ of Japan. *Journ. Coll. Sci. Imp. Univ., Tokyo*. Vol. xvii. 17 pp., 2 pls. — KUSANO, S. Studies on the Parasitism of Buckleya Quadoriala, B. & H., a Santalaceous Parasite, and on the Structure of its Haustorium. *Journ. Coll. Sci. Imp. Univ., Tokyo*. Vol. xvii. 46 pp., 1 pl. — MCKENNEY, R. E. B. Observations on the Conditions of Light Productions in Luminous Bacteria. *Proc. Biol. Soc., Wash.* Vol. xv, pp. 213-234. — MONACO, PRINCE A. DE. Sur la troisième campagne de la Princesse Alice II. *Compt. Rend. Acad. Sci., Paris*. Tome cxxxiv, pp. 961-964. — MOSER, J. F. The Salmon and Salmon Fisheries of Alaska. Report of the Alaskan Salmon Investigations of the United States Fish Commission Steamer *Albatross* in 1900 and 1901. *Bull. U. S. Fish Com. for 1901*. Pp. 173-401. 45 pls., maps. — OSHORN, H. F., and LAMBE, L. M. Contributions to Canadian Palæontology. Vol. iii, pt. ii. On Vertebrata of the Mid-Cretaceous of the Northwest Territory. *Geol. Survey, Canada*. 4to, 81 pp., 20 pls., 24 text-figs. — RATHBUN, MARY J. Japanese Stalk-Eyed Crustaceans. *Proc. U. S. Nat. Mus.* Vol. xxvi, pp. 23-55. 24 figs. — RATHBUN, MARY J. Descriptions of New Species of Hawaiian Crabs. *Proc. U. S. Nat. Mus.* Vol. xxvi, pp. 75-77. 4 figs. — RICHMOND, C. W. Birds collected by Dr. W. L. Abbott and Mr. C. B. Kloss in the Andaman and Nicobar Islands. *Proc. U. S. Nat. Mus.* Vol. xxv, pp. 287-314. — RICHMOND, C. W. Description of a New Subspecies of *Stenopsis Cayennensis* from Curaçao. *Proc. Biol. Soc., Wash.* Vol. xv, pp. 159-160. — SNODGRASS, R. E. Papers from the Hopkins Stanford Galapagos Expedition. VIII. Entomological Results: (7) *Schistocerca*, *Sphingonotus*, and *Halemus*. *Proc. Wash. Acad. Sci.* Vol. iv, pp. 411-454. Pls. XXVI-XXVII. — STARKS, E. C. The Shoulder Girdle and Characteristic Osteology of the Hemibranchiate Fishes. *Proc. U. S. Nat. Mus.* Vol. xxv, pp. 619-634. 6 figs. — VAUGHAN, T. W. An Addition to the Coral Fauna of the Aquia Eocene Formation of Maryland. *Proc. Biol. Soc., Wash.* Vol. xv, pp. 205-256. — VAUGHAN, T. W. A Redescription of the Coral *Platytrachus Speciosus*. *Proc. Biol. Soc., Wash.* Vol. xv, pp. 207-209. — WILDER, H. H. Animal Classification. — WILDER, H. H. A Synopsis of Animal Classification. New York, Henry Holt & Co., 1902. 8vo, iii + 57 pp.

